Digitized by the Internet Archive
in 2010 with funding from
University of Toronto

http://www.archive.org/details/chemicalengineer20newy

Chemical & Metallurgical Engineering

A Semi-monthly Technical Newspaper,
Being the Incorporation of
Electrochemical and Metallurgical Industry
and Iron and Steel Magazine

Volume XX

From January 1 to June 15, 1919

436845
3. 7. 45

NEW YORK:
McGRAW-HILL COMPANY, Inc.

INDEX TO VOLUME XX

GENERAL ALPHABETICAL INDEX

*Entries from the Synopsis of Periodical Literature are indicated by S; from the Analysis of Current Electrochemical, Chemical and Metallurgical Patents by P; Papers read at society meetings but not printed in full are indicated by N. Illustrated articles are indicated by **

A

Acetic acid, From wood pulp waste..... 542
——Manufacture, Dreyfus. (P.)..... 248
Acetone, From wood, Bassett..... 190
——From wood pulp waste..... 542
Acid eggs, Cast iron, Bursting of. (S.)... 433

ACID:

——Mixed, Action on cast iron. (S.).... 433
——Mixed, Plant at Nitro..... *406
——Surplus, War Department..... 319
Air conditioning 405
Alaska, Ammoma leaching at Kennecott.. 328
Albumen glues 601
Alcohol, Methyl, From wood pulp waste.. 542
Alien Property Custodian, Report on chemical industries 264
——Report on metal industry 313

ALLOYS:

——Acid-proof, Rossi. (P.)..... 597
——Aluminium-Tin, Equilibrium diagram. 423
——Chemically reactive. (S.) 594
——Chromon. 437
——Colloid-chemical nature. Alexander. (N.) 212
——Copper-aluminium, Equilibrium diagram 424
——Copper, Determination of phosphorus in 58
——Magnesium-lead. (S.) 594
——Norwegian bronze 179
——Silicon, Hydrogen from *289
——Steel, Flakes in *216
——For helmets and armor, Coyle.... 618
——Zinc-copper-aluminium, Guillet and Bernard. (S) 645
——Zinc-iron 530
Almaden, Spain, Mercury production at, Sterner-Rainer *32

ALUMINA:

——Beta, Saunders. (P.)..... 87
——Crystalline, Tone. (P.)..... 87
——From impure bauxite, Saunders. (P.) 87
——Production, Larson. (P.)..... 487
——Purification, Hornsey. (P.)..... 487
——Purification, Saunders. (P.)..... 87

ALUMINIUM:

——Bronze, Die casting of, Rix. (S.).. 135
——Bronze industry, Morse..... 212
——Bronze, Properties of 163
——Diseases of *280
Alunite, Potassium sulphate from, Chappell. (P.) 249
Ambrine treatment for burns 288
American Bureau of Welding, Election of officers 456
American Ceramic Society, Pittsburgh meeting 180
AMERICAN CHEMICAL SOCIETY:
——Buffalo meeting, Report..... *390

AMERICAN ELECTROCHEMICAL SOCIETY:

——New York meeting, Program..... 273
——Report *379
——Fall meeting, Announcement 616
——Pittsburgh Section 31
American Electroplaters' Society, Research fund 501

AMERICAN INSTITUTE OF CHEMICAL ENGINEERS:

——Boston meeting, Announcement..... 334
——Program 504
——Chicago meeting, Program..... 37
——Report of..... *115
AMERICAN INSTITUTE OF MINING ENGINEERS:
——Chicago meeting, Announcement..... 505
——New York meeting, Program 101
——Report *208
——Pyrometry symposium, Program.... 455
American Paper and Pulp Association:
——New York meeting *184
Americaa Metal Co., German-owned shares sold 430
American-Scandinavian Foundation 505
American Smelting and Refining Co., Report 615
American Welding Society 265
——1st meeting, New York..... 400

AMMONIA:

——From cyanides and ferrocyanides. (P.) 431
——From cyanamide. Muscle Shoals.... 14
——Leaching of copper ores. Eddy..... 328
——Nitric acid from. Landis. (P.)..... 431
——Oxidation of. Landis..... 470
——Oxidation of. Parsons. (N.)..... 502
Ammonium nitrate, Controlling crystallization. Bolling 401
——Perryville plant *320
——Phases of 321
——Production at Muscle Shoals..... *17
Ammonium perchlorate, Aanensen. (P.) 597
Ammonium sulphate, Production. Larson. (P.) 487

ANALYSIS:

——Aluminium in plain steel 588
——Chromium in steel 589
——Copper, Electrolytic, without rotating cathode 452
——Ferromanganese 53
——Jones reductor for steel 523
——Nickel in steel, Modified cyanide method. Miller. 613
——Phosphorus in copper alloys..... 58
——Potash in cement by perchloric acid method 452
——Red lead, Edwards 35, 260
——Sulphite liquor. Baker. (N.)..... 185
——Sulphur dioxide in gases. (S)..... 541
——Uranium in chrome tungsten steel... 524
——Uranium in plain steel..... 523
——Vanadium in steel 589
——Zirconium in steel 588
Aniline hydrochloride. Ahlum. (P) ... 648
Anti-dumping law advocated..... 116
Anti-freezing mixtures containing calcium chloride. Rudnick. (N.)..... 394
Apparatus, Chemical, Buflokast *395
Arc welder, Portable 436
Argentina, Linseed production 220
Armor, Alloy Steels for. Coyle 618
Arndt gas balance *291
Asbestos, Platinized. Frabetti. (P.)..... 487
Ash, Coal, Fusibility of. Selvig et al.... 274
Ashpit door, Air tight..... 598
Asphaltic sandstone, Extraction of kerogens from 31
Australia, Dye importation prohibited.... 420
Auto-recorder, CO_2 ..... *243

B

Ball mills, Fine crushing in, Davis. (N.) 210
Barium industry, Future of. Rollin..... 163
Barium products, Uses of..... 164
Bartlesville Zinc Co., Sintering zinc residues, Stock *525
Bauxite, Purification of. Saunders. (P.) 87
Bearings, Detecting overheating of..... 577
Beer Sondheimer & Co., Organization.... 316
Beet-sugar, Production in Utah and Idaho 560
Belting for power trasmission. Wilson. (N.) 117
Belting, Leather, Specifications. (S.).... 543
Benzol, French production 57

BIBLIOGRAPHIES:

——Chemical literature:
—— Biochemistry 580
—— Mining and metallurgy 580
—— Organic 578
——Cottrell, F. G., Articles and patents... 114
——Metallic coatings for rust-proofing iron and steel 591
——Milling calculations. Lewis..... 233
Bi-meter CO_2 recorder *243
Bituminous roofing materials. Wilson. 425, 484
Black Hills Mining Men's Association.... 207
Black sand deposits in..... 79
Black sands, Platinum in..... 101
Blistering in sheet steel enamel. (N.).... 182
Blood albumen glues 601
Boiler plants, Fuel economy in. Kershaw. 176, *241, *291

BOOK REVIEWS:

——Allen. Mill and Cyanide Handbook... 361
——Auld. Gas and Flame in Modern Warfare..... 439
——Ellis. Hydrogenation of Oils..... 601
——Ferry. Handbook of Physical Measurements 438
——Gill. Handbook of Oil Analysis..... 90
——Hale. Applications of Electrolysis in Chemical Industry 438
——Johnson. Principles, Operation and Products of the Blast Furnace.... 438
——Laucks. Commercial Oils..... 602
——Lunge. Technical Chemists' Handbook 90
——Manlove and Vickers. Scrap Metals. 194
——Megraw. Flotation Process 440
——Morgan. Organic Compounds of Arsenic and Antimony 90
——Shuey. Bibliography of Foreign Trade Publications 136
——Smith. Electro-Analysis 601
——Smith. The Zinc Industry..... 136

BOOK REVIEWS—*Continued:*

——Steinmetz. General Lectures in Electrical Engineering 439
——Villavecchia. Treatise on Applied Analytical Chemistry 439
——Wile. Explaiming the Britishers..... 438
Boxes, Metal strapping on..... 483
Brass, Cartridge, Comparison of grain-size and Brinell hardness. (N.)..... 212
——Corrosion in sea water. Bruhl..... 239
——Influence of certain variables on anneal of cold-worked alpha brass. Phillips and Gerner..... *622
——Pyrometer for 436
Brick, Manufacture at Kingsport..... 568
Briquetting brittle metals. Vogel. (P).. 647
British Columbia, Electric pig iron for... 206
——Electric smelting, Commercial feasibilty 630
——Mineral production, 1918..... 148
British import restrictions.....189, 288, 600

BRONZE:

——Alloy, Norwegian 179
——Aluminium, Die casting. Rix. (S.). 135
——Aluminium, Properties of..... 163
——Manganese, Manufacture. (N.).... 212
——Phosphor, Properties of..... 163
——Pyrometer for 430
Brooklyn, Polytechnic Institute dinner.... 505
Bucher process, Davis. (N.)..... 394
Buffalo, American Chemical Society meeting *390
Buffalo Foundry & Machine Co..... *395
——Vacuum drum drier..... *642
Buflokast apparatus, Making..... *395
Bureau of Mines, Mesothorium research.. 168
——New laboratories in Pittsburgh..... 617
Bureau of Standards, Electroplating work. 501
——Standard samples, Distribution of.... 276
Burns, Treatment of..... 288
By-products, Principles of. Steinmetz. (N.) 184

C

Cable, Hoisting, Failure of. Robertson. (N.) 263
Calcium carbide, Preparing charge for. Becket. (P.) 431
Calculations, Milling. Lewis..... 224
California, Chromite deposits in..... 79
——Manganese and chromium in..... 319
——Mineral production, 1918..... 149
Calignate, Acetone and methyl alcohol from. (S.) 542
Calumet & Arizona Mining Co., Report.. 615
Cambridge bi-meter CO_2 recorder..... *243
Canadian graphite industry 81
Canadian Mining Institute:
——21st Meetiog, Announcement 136
—— Report 262
Carbazol, Purification of. Weiss. (P.).. 596
Carbon Dioxide, Novel use..... 185
Carbon dioxide recorders, see Recorders, carbon dioxide.
Case-hardening, Shirmer. Richards. (N.). 213
Casting tools, Davidson process. Johnson. (N.) 213
Castings, Chemical, Pouring..... *396
Castings, Die, Pack. (N.)..... 212
Caustic Pots, Furnace settings, Nickle... *65
——Correction 261
Caustic Soda, French production..... 58
Celluloid-glass lenses, Rosenthal. (N.).. 504
Celluloid, Substitute, Zeisberg. (P.).... 296
Cement, Blast furnace slag-lime-gypsum.. 25
—— Resistance to sulphate corrosion... 28
—— Tests of..... 25
——Manufacture at Kingsport 568
Census of chemical imports 562
——Comment by Bernhard C. Hesse..... 559
Centrifugal agitator. Jacoby..... 598

CHARTS:

——Showing use of exhaust steam..... 18
——Alignment:
—— Indentation of steel balls under pressure 192
—— Power data for electrolytic zinc. Supplement to Feb. 15.
Chemical Alliance, Export statistics..... 295
——New York meeting 100
Chemical elements, Melting points of..... 351
Chemical Engineer, Modern training of. McKee. (N.)..... 503
Chemical Exposition plans 561
Chemical Foundation, Organization of.... 265

CHEMICAL INDUSTRY:

——At Kingsport, Tenn.....*565, *639
——Engineering research in. Field..... 84
——Foreign competition in..... 118

CHEMICAL INDUSTRY, *Continued*:
——Foreign trade, Aids to 189
——German methods, Choate, (N.) 392
——In France during war, Maoussa 56
—— (S.) 542
——Intelligent location of 311
——Made permanent, Thompson 118
——Organic, Future of, Hibbert 335
——Organization of 123
——Present conditions in, Toch, (N.) .. 116
——New Jersey, Recent developments, (N.) 39
——Reconstruction aspects, Gudeman, (N.) 116
——Report of Alien Property Custodian. 264
——Tariff Commission and, Culbertson, (N.) 392
Chemical literature, Art of searching, Hibbert 578
Chemical market
44, 92, 139, 196, 251, 299, 363, 443, 490, 546, 603, 650.
Chemical specifications, Cohoe 539
Chemical warfare, Effectiveness, Hendrick 152
Chemical Warfare Service, Pershing confirmands 601
Chemical war secrets, Gudeman, (N.) .. 117
Chemists' Club Scholarships 620
Chicago, Amer. Inst. of Chem. Eng. meeting *115
Chile, Instituto Cientifico Industrial 205
Chloridizing complex ores 207
Chlorine, French production 57, 542
Chlorine in sanitation 414
Chromite, Concentration of 80
Chromium, Canadian practice, (N.) 263
Chromon, Pyrometer protection tubes 437
Civil Service examinations: 318, 399, 589, 618
Claude helium plant at Fort Worth *110
Clays, American, Maynard, (N.) 185

COAL:
——Ash, Fusibility of, Selvig et al. 274
—— Pennsylvania, Selvig and Fieldner 629
—— Improved furnace for fusion point, Lovejoy 538
——Clinchfield, Analysis of 567
——Distillation at low temperatures 78
——Lubricating oils from 79
——Powdered, For blast furnaces, Wotherspoon, (N.) 263
——Powdered, Nodulizing flotation concentrates with, Draper 621
Coal tar products, Tariff amendments 179
Colloidal silver chloride 260
Colloid-chemical viewpoint of metals, Alexander, (N.) 212
Colloids in Flotation, Reply to criticism ... 52
Colorado Fuel & Iron Co., Americanization work *529
Combustion, Surface, Roasting by, McCourt, (P.) 297
Compensation laws, Need of revision 416
Concentrates, Flotation, Roasting, Fullam, (P.) 86
Concentrating system, Gahl, (P.) 432

CONCRETE:
——As chemical engineering material, Toch 222
——Defects of 222
——Methods for protection of 223
——Tanks, Reinforced, Frerichs 234
——Waterproofing 222
——Work at large acid plant 408
Condenser tubes, Corrosion of, (S.) 594
Coniagas Mines, Ltd., Report 149
Consolidated Arizona Smelting Co., Report 616
Construction and Operation
47, 95, 142, 199, 255, 303, 366, 446, 495, 550, 607, 654.
COPPER:
——Alloys, Determination of phosphorus in 58
——Analysis, Electrolytic, without rotating cathode 452
——Coating steel with, Silverman, (N.) 211
——Companies, Employees to meet Secretary of Labor about 136
——Cupro-phosphorus, Jeffs, (P.) 249
——Electrolytic refining, Laboratory plant, Hayward *240
——Flotation concentrates, Nodulizing, Draper 621
——Flotation plant at Ohio Copper Mill. 6
——Iron for precipitating, Johnson, (P.) 596
——Leaching oxidized ores 559
——Ores, Ammonia leaching of, Eddy .. 328
——Plating, Automatic, Richards, (N.) 211
——Production and price 455
——Recovery from sulphate solution, (P.) 432
——Russian smelter equipment, Carlyle, (N.) 263
——Volatilization of cuprous chloride on melting, (N.) 211
Cores for chemical castings *396
Corrosion, (See also Metal protection)
——Brass in sea water, Bruhl 239
——Condenser tubes, (S.) 594
——Nature of 458
——Bibliography 591
Cottrell, F. G., Bibliography of articles and patents 114
Cottrell precipitator, At Kingsport 569
——Effect of dielectric deposits, (S.) ... 89
——History of, Chandler 103
——In alkali pulp industry, (N.) 184
——In metallurgical plants, Thum *59
——Portable, Lamb, (N.) 386
Crane, Locomotive, Specifications, (S.) .. 433
Cripples, Use of in industry, Munroe, (N.) 210
Crystal crushing, Example of 72, 309
Crystals, Growth of, (S.) 595
Crystallization control, Bolling 401
Cuprodesclozite, Vanadium, lead and copper from, Conley 465
Cupro-phosphorus, Jeffs, (P.) 249
Cuprous chloride, Volatility, (N.) 211
Current Market Reports
42, 91, 137, 194, 250, 298, 362, 441, 489, 545, 602, 649.
Cyanamide, French production 57
Cyanamide Process at Muscle Shoals 9, 13
Cyanide plants, Calculating extraction ... 225
Cyanides, Alkali, Ammonia from, (P.) ... 431
—— Separation from hydroxide, Metzger, (P.) 431

D

Davidson tool-casting process, Johnson, (N.) 213
Decomposition of metals, Krynitzky. *277 *421
—— Correction 501
Deformation, Effect on mechanical properties of metals, Jeffries, (N.) 211
Denitrating plant at Nitro, Hollister *406
Depolarizers, Manganese dioxide, (P.) 432
Die casting of aluminium bronze, Rix, (S.) 135
Die castings, Pack, (N.) 212
Dielectric deposits, Effect on Cottrell process, (S.) 89
Disabled men, Opportunities for 319
Distillation of coal at low temperatures ... 78
Drier, Vacuum drum *642
Dye plant, Use of exhaust steam in 18
Dyes, French production 58
——Sulphur, Manufacture at Kingsport .. 639
——Tariff, Proposed amendments 70

E

Econometer, Arndt *291
Ecuador, Salt monopoly in 188
Edgewood Arsenal, Illustrated souvenir .. 469
Edgewood Arsenal, Walker, (N.) 386
——New commanding officer 636

EDITORIALS:
——Abolish duty-free imports of chemicals 201
——Alignment of the steel industry 451
——An appraisal of the American potash industry 306
——The blight of blatherskite rule 257
——Bolsheviks and research 450
——Capacities well aligned in the iron industry 51
——The Chemical Foundation and confiscated German patents 554
——Chemical industry and the Victory Loan 370
——Chemistry, metallurgy, and the high cost of living 371
——Cinematic micrography 499
——Commodity values and construction work 307
——Debating price mobilizing industry. 259
——Dislocation of the copper industry .. 145
——The duration of prosperity 611
——An engineering opportunity—the by-product coke oven 2
——Faith in our friends and allies across the Atlantic 50
——Favorable prospect for water-power legislation 202
——The first great step 554
——German chemical patents take on new aspects 258
——The gold producer and political economist 1
——Government control of markets 499
——Hard times for inventors 202
——Has heat treatment been demonstrated? 449
——Iron and steel in last year of war ... 5
——Iron and steel production in 1917 203
——The iron map of Europe 99
——Metallurgy and civilization 258
——The metallurgy of copper in 1918 4
——Minerals Separation wins doubtful victory 609
——National integrity, personal responsibility and the Victory Loan 449
——A new view of gas warfare 145
——Nitro-aromatics vs. nitroglycerine ... 306
——An opportunity for co-operative research 498
——The outlook of the optimist 49
——Pan American engineering literature. 1
——The passing of a friend 369
——A penalty on Western residence 553
——The philosophy of buying at present high prices 370
——Post-war meetings of scientific societies 201
——Progress in zinc smelting awaits impulse from metallurgists 202
——Promise of progress in rubber research 610
——Proposed improvements in American patent procedure 146
——Railroads and industrial research ... 370
——Readjustment and resumption 555
——Research forbidden to railway companies 306
——A resolution of forces 371
——Restoring the dollar's value 147
——The rude awakening 497
——Scholarships in Sweden 498
——Scrapping war chemicals 97
——Scrutable in the penultimate 50
——Speaking of propaganda 257
——Sulphur patents are decreed invalid .. 259
——Teach engineering students how to study—first 98
——Validation of informal contracts 201
——Wanted: A guardian for the United States 369
——Warning! Beware the gas-mask! 305
EDITORIALS, *Continued*:
——The way to prosperity 450
——What of industrial opportunities in France? 97

EDUCATION:
——Americanization work by Colorado Fuel & Iron Co 529
——Business training for engineers 564
——Chemical Engineering, McKee, (N.) 503
——Industry, democracy and, Corliss, (N.) 208
——Mining schools in Nevada 148
——Vocational, In paper industry 185
Electrical Precipitators, E. E. Thum *59
Electric power production by states 617
Electrochemistry in its human relations, Tone 413
Electro-deposition plant, Laboratory, Hayward *240
Electrodes, For Cottrell precipitator 62
Electrons, Arrangement in atoms and molecules, Langmuir, (N.) 393
Electrostatic precipitation, Braley, (N.) 384
Elements, Chemical, Melting points of 351
Ellison gage, Zero point, Bacharach *246
Enameled steel, Blistering of, (N.) 181
Enamels, Simple chemical tests for, (N.), 181
Engineer as citizen, Symposium, Program 270
—— Report 377
Engineering Council, National Service Committee 114
Engineering research, Field 84
Engineering, "Wild," Wesson 512
Engineers, Business training for 564
England, Industrial research in 390
——Tungsten in, (S.) 594
Europe, War-time trip to, Parmelee *124
Evaporation of small spheres, Langmuir, (S.) 135
Exhaust steam at high back pressures, Field 18
Explosives, Nitro-aromatics in 311
EXPORT STATISTICS:
——Digest, Chemical Alliance 295
——Caustic soda, Dec., 1918 219
—— Jan., 1919 334
—— Feb., 1919 492
—— Mar., 1919 593
—— April, 1919 617
——Copper, Jan., 1919 334
—— Feb., 1919 492
—— Mar., 1919 593
—— April, 1919 617
——Glycerine, Dec., 1918 219
—— 1918 288
—— Jan., 1919 334
—— Feb., 1919 492
—— Mar., 1919 593
——Gold and silver, 1918 136
——Lead pigs, bars, etc., Dec., 1918 295
—— Jan., 1919 400
—— Feb., 1919 492
—— Mar., 1919 644
——Platinum (Canada), Dec., 1918 295
——Soda ash, Dec., 1918 219
—— Jan., 1919 334
—— Feb., 1919 492
—— Mar., 1919 593
—— April, 1919 617
——Tin plate, terne plate and taggers tin, Dec., 1918 219
—— Jan., 1919 400
—— Mar., 1919 593
——Tungsten and ferrotungsten, Dec., 1918 295
—— Jan., 1919 400
—— Mar., 1919 644
——Zinc, Dec., 1918 295
—— Jan., 1919 400
—— Feb., 1919 492
—— Mar., 1919 593
—— Mar., 1919 644
Extraction, Computation of 224

F

Ferro-alloys, At Heroult 613
——Production costs 636
FERROMANGANESE:
——Adding in ladle 52, 53, 501, 612
——Analysis of 53
——At Great Falls, Mont 7
——Blast-furnace production, Royster, (N.) 215
——Eliminating phosphorus and sulphur, Lonergan 245
Ferromolybdenum, Westling, (P.) 249
Ferrophosphorus, Webster, (P.) 249
Ferrosilicon, Johnson, (P.) 249
—— Furness, (P.) 249
Ferrotungsten in England, (S.) 595
Filterpress, Calculating capacity of 230
Firebrick, Improved furnace for fusion point, Lovejoy 538
Flakes in alloy steel *216
Flakes in steel, Styri *342, 478
——Correction *453
——Criticism, Feild 556
—— Reply, Styri 557
FLOTATION:
——Bradford preferential, Dean 372
——Colloids in, Reply to criticism 52
——Concentrates, Nodulizing in rotary kiln, Draper 621
——Concentrates, Roasting, Fulton, (P.) 86
——Effectiveness of 573
——Experiments on hardwood tar oils, Hawley and Ralston 586
——For the practical mill man, Moses .. 571
——Galena, From mixed sulphide ores, Read, (P.) 544
——Hand device for experiments, Coghill *537

FLOTATION—*Continued.*
——Importance of pure water..... 574
——Lead ores, Allen 169
——Oils from crude tar..... 341
——Plant at Ohio Copper Mill..... 6
——Preferential. Edser and Tucker. (P.) 597
——Recleaning concentrates 576
——Recoveries 571
——Recovering pulp from waste liquor by. (N.) 184
——Slime removal 572
——Sulphidizing 559
Foreign trade, Aids to..... 189
France, Chemical industry during war, Maoussa. .....56 (S.)
Frasch sulphur patents. Court decision. Mock and Blum 542
Fuel economy in boiler house. Kershaw. 176, *241, *291 637

FURNACE, BLAST:
——By-products. Gayley. (P.)..... 432
——Cement from slag. Bereslavsky..... 25
——Ferromanganese in. Royster. (N.). 215
——Gases, Dry cleaning. Barrett..... *359
——Potash from. Criticism..... 308
—— Reply 373
——Potash from gases. (P.)..... 432

FURNACE, ELECTRIC:
——General:
—— Problems. Yardley 212
—— Large vs. small..... 374
—— Temperature uniformity in. Ferguson 283
—— Transformers for *600
——Various Designs:
—— Northrup induction. Theory. (N.) 381
—— Resistance, Granular carbon, For fusion point of coal ash. Lovejoy 538
—— Vom Baur *488
——Products:
—— Calcium Carbide at Muscle Shoals. 11
—— Cyanamide at Muscle Shoals..... 13
—— Ferro-alloys at Heroult..... 613
—— Ferromanganese 7
—— Ferromanganese. Eliminating phosphorus and sulphur. Lonergan.. 245
—— Ferrosilicon, Furness. (P.) 249
—— Molybdenum, Escard. (S) 645
—— Pig and sponge iron at Heroult.. 613
—— Pig iron, British Columbia....206, 630
—— Pig iron. Turnbull 178
—— Silicomanganese. Kluzh. (N.)..... 388
—— Steel, Armor, Nickel-manganese.. 618
—— Power costs 74

FURNACE, OPEN HEARTH:
——Manganese alloys used in. Hoyt. (N.) 215
——Refractories, Basic. (N.)..... 213
——Water cooled. Coffin. (N.)..... 213

FURNACE, MISCELLANEOUS:
——Caustic *65
——Cermak-Spirek. Mercury..... 34
——Bustamente, Mercury..... 33
——Gas-fired caustic pot furnaces..... 68
——Preparing calcium carbide charge. (P.) 431
Fusibility of coal ash. Selvig, Ratliff and Fieldner 274

G

Gage, Ellison, Zero point. Bacharach.... *246

GAS AND GASES:
——Continuous testing for acid or alkali. King. (S) 645
——Flue, Automatic sampler..... *294
——Furnace, Dry cleaning. Barrett..... *359
——Liquefaction of. Claude system..... *112
—— Linde system..... *112
—— Jeffries-Norton system *112
——Masks, Industrial 188
——Masks, Limitations for industrial use 220
—— Use in SO_2 industries. Fieldner and Katz. *582
——Natural, Helium from..... 107
——Producers, Slagging 192
——Refractive indices, Table of..... 292
——Reversing valve..... 435
——Roaster, Sulphur from. Foster. (P.) 545
——Sulphur dioxide determination. (S) 541
Gas warfare, see chemical warfare.
German metal combination 314
German requisitions in Poland..... 265
Germany, Scarcity of raw materials. (S.) 541

GLASS:
——American scientific. Howe. (N.)... 504
——Celluloid-glass lenses. Rosenthal. (N.) 504
——Optical, Gases in. (N.)..... 182
—— Defects. (N.)..... 182
—— Improved process. Morey..... 511
—— Testing. (N.)..... 182
—— Manufacture. (N.)..... 182
——Industry, Future needs. Bleiniger. (N.) 504
Glass Pots, Manufacture of. (N.)..... 182
Glue, Liquid, Specifications..... 430
——Water-resistant 601

GOLD AND SILVER: (See also Silver).
——From manganese ores. Caron. (P.) 544
——Mobility in solid state. Keller. (N.) 212
——Precipitation without filtration. Lockwood. (P.) 544
——Production. 1918 188
——Refining. Wohlwill. Griswold. (N.). 382
Goldfield Consolidated Mines Co., Passing of 207

GOVERNMENT:
——Ammonium nitrate plant *320
——Ownership of water power. (N.)... 380
——Surplus supplies, Disposal of:
—— Policy 215, 236
—— Alcohol 505
—— Caustic soda 375
—— Copper 375, 505
—— Lead 464
—— Soda ash 375
—— Sodium nitrate 505
—— Spelter 424
—— Sulphur 505
Grain size, Effect on mechanical properties of metals. Jeffries. (N.).... 211
Grand Forks smelter, Correction..... 7
Graphite, Canadian 81
Graphite symposium. (N.)..... 180
Gravel roofs..... 484
Grog, Effect of size in fire clay bodies. (S.) 88
Gypsum, Influence on blast-furnace slag cement. Bereslavsky 25

H

Hadfield's manganese steel 618
Hardening machine. Jackman and Squire. (P.) 647
Hardwood tar, Flotation oils from....341, 586
Health standards for foundries. Erskine. (N.) 213
Helium, Commercial production of. Cottrell *104
Helmo's, Alloy steels for. Coyle 618
Heroult, Pig iron, ferros and spooge iron at 613
Hird process for tar distillation..... 534
Hirsch, Aron, und Sohn, organization.... 315
Humidity, control in large plant..... 403
Hydrocyanic acid, Manufacture of. Pelton and Schwartz 165

HYDROGEN:
——Preferential catalyses in purification of. Taylor. (N.)..... 393
——Recorder. Harger *191
——Silicol process *289

I

Idaho, University of, Research fellowships. 528
Illinois, University of, Research vacancies. 151
Import license, New general..... 424
Import license proposed 456
Import Restrictions, British.....189, 288, 600

IMPORT STATISTICS:
——Census of Chemical Imports.....38, 562
——Comment by Bernhard C. Hesse.. 559
——Copper, Jan., 1919..... 334
—— Feb., 1919 492
—— Mar., 1919 593
—— April, 1919 617
——Glycerine, Dec., 1918 219
—— Jan., 1919 334
—— Feb., 1919 492
—— Mar., 1919 593
——Gold and silver, 1918 136
——Iridium, Dec., 1918 295
—— Feb., 1919 492
—— Mar., 1919 593
——Lead and ores, Dec., 1918..... 295
—— Jan., 1919 400
—— Feb., 1919 492
—— Mar., 1919 644
——Platinum, Dec., 1918 295
—— 1918 288
—— Feb., 1919 492
—— Mar., 1919 593
——Tin bars, blocks, pigs, etc., Dec., 1918 219
—— Jan., 1919 400
—— Feb., 1919 492
—— Mar., 1919 593
——Tungsten ores, Dec., 1918 295
—— Jan., 1919 400
—— Feb., 1919 455
—— Mar., 1919 644
——Zinc, Jan., 1919 400
—— Feb., 1919 492
—— Mar., 1919 593
—— Mar., 1919 644
Indentation of steel balls under pressure. 192
Indigo, Synthetic, French production... 58
Indophenol, Manufacture at Kingsport... 640
Industrial casualties, Salvaging. McMurtrie 415
Industrial gas masks 188
Industrial News
47, 95, 142, 199, 255, 303, 366, 446, 495, 550, 607, 654.
Industrial Notes
96, 143, 200, 256, 367, 447, 496, 551, 608, 655.
Industrial organization. Mental factors. Read. (N.)..... 210
Industrial relations. Wilson. (N.)..... 209
Industrial research in England..... 399
Industrial wastes, Reclaiming. Hall..... 327
Industry, democracy and education. Corless. (N.) 208
Industry, Mental tests in. Yerkes. (N.) 210
Industry, Use of cripples in. Munroe. (N.) 210
Inspiration Consolidated Coal Co., Report 610
Instituto Cientifico Industrial, Chile..... 205
Insulators, For Cottrell precipitator..... 62
Interalied Chemical Confederation 561
Interstitial space, Calculation of..... 230
Iodine from seaweed. Bredenburg. (P.). 487
Iron & Steel Market
43, 91, 138, 195, 250, 298, 362, 441, 490, 546, 602, 650.

IRON AND STEEL:
——General:
—— Corrosion of. See Corrosion; also Metal protection.
—— Enameled steel, Blistering of. (N.) 182
—— Iron for precipitating copper, Johnson. (P.) 596
—— Metallurgical Society 7
—— Rust-proofing. See Metal protection.
——Economics:
—— Commercial feasibility of electric smelting in British Columbia..... 630
—— Electric pig iron after war 178
—— Electrochemistry's role 414
—— Reclaiming steel works waste. Hall. 327
——Analysis and Physical Tests:
—— Aluminium in plain steel. 588
—— Aluminium, Separation from zirconium 588
—— Chromium and vanadium 589
—— Determination of U, Zr, C, V and Al in steel, Johnson.....523, 588
—— Indentation of steel balls under pressure. (S.) 192
—— Nickel by modified cyanide method. Miller 613
—— Relation of hardness to tensile tests. (S.) 595
—— Silky structure on fracture 72, 309
—— Toughness, Static, dynamic and notch. Hoyt. (N.) 213
—— Uranium in chrome tungsten steel. 524
—— Uranium in plain steel 523
—— Vanadium and chrominm 589
—— Zirconium, Separation from Al and Fe 588
——Heat Treatment:
—— Fundamental principles. Hayward. 519
—— Heating prior to quenching. Giolitti. (P.) 544
—— Heat-treating shells. Hall. (S.). 193
—— Criticism 374
—— Holmets 618
—— Locomotive crane parts. (S.)..... 433
—— Malleableizing cast iron. (P.)... 487
—— Physical tests on heat treated steel. 521
—— Pyrometric control 521
—— Quenching practice 520
—— Shirmer case-hardening process. Richards. (N.) 213
—— Temperature observations on large steel forging. Knight and Hansen 590
——Metallography:
—— Divorce of pearlite after cold working. (S.) 192
—— Flakes in alloy steel..... *216
—— Flakes in steel. Styri *343, 478
—— Correction *453
—— Criticism. Feild 556
—— Reply. Styri 557
—— Flaky and woody steel. Giolitti.. *271
—— Grain boundaries in alloy steels. Archer. (N.) 213
—— Motion microphotographs..... *509
—— Recrystallization of steel..... *279
——Properties and Specifications:
—— Brittleness due to pickling..... 535
—— Locomotive crane parts. (S.)..... 433
—— Relation of hardness to tensile tests 595
—— Resistance of steel to fatigue, Effect of cold-working on. (N.)..... 215
—— Rupture of cast iron in contact with mixed acid. (S.) 433
—— Specific density of steel, Effect of forging on. Doerr. (N.)..... 213
——Electric Furnace:
—— Castings, Electric *190
—— Nickel-manganese armor steel, Manufacture of 618
—— Pig and sponge iron at Heroult.... 613
—— Pig iron, British Columbia....206, 630
—— Pig iron, Turnbull 178
—— Power costs 73
—— Swedish practice 631
——Iron Manufacture:
—— Electric pig iron, British Columbia 206, 630
—— Electric pig iron, Turnbull..... 178
—— Malleableizing cast iron. (P.)..... 487
—— Pig iron at Heroult..... 613
——Steel Manufacture:
—— Alloy steel, High grade, Howe. (N.) 214
—— Armor, Nickel-manganese 618
—— Flaky and woody steel. Giolitti... *271
—— High speed steel substitutes. (P.).. 248
—— Manganese steel. Nichols. (P.)... 296
—— Nicu steel 88
—— Wheels, Davison one-piece *190
Italian import restrictions 437

J

Japan, Industrial notes..... 518
——Trade expansion during war..... 319
Johns Hopkins scholarship 564
Johnson, Joseph Esrey, Jr. An appreciation 376
Jones spur gear speed reducer *648
Joplin Zinc Situation 6

K

Kelp industry, Collapse of 206
Kennecott, Alaska, Ammonia leaching at. 328
Kerogens in oil-bearing shales..... 29
Kilns, Cement, at Kingsport..... 569
——Lime, Continuous gas-fired. Mount.. *428
——Tunnel, Types of. Harrop. (N.).... 39
Kingsport, Chemical industries at....*565, *639
Krell CO_2 recorder *291

L

Lactonic acids from wood pulp waste... 543
Launders, Formulas for ... 230
Leaching, Results at New Cornelia Copper Co. (N.) ... 212
LEAD:
——Arsenate, Lytle. (P.) ... 487
——Burning at large acid plant ... 410
——Coated iron sheet, Baskerville. (N.) ... 394
——Flotation of oxidized ores, Allen ... 169
——Pigment, Production in U. S. ... 38
——Plating, Reeve. (N.) ... 388
——Plating, Pitting during, Watts (N.). ... 384
——Poisoning ... 477
——Red lead, Analysis of ... 35, 260
——Red lead, Production in U. S. ... 38
——Reinforced, Baskerville. (N.) ... 394
——Sulphidizing ore, Allen ... 169
——White lead, Production in U. S. ... 38
Leather belting specifications. (S.) ... 543
Legislation, Water power, Deadlock ... 151
Lenses, Celluloid-glass, Rosenthal. (N.) .. 504
Lenses, Resolving powers, Table of ... 510
Library service in industrial laboratories. (N.) ... 391
Lignin, From wood pulp waste ... 543
Lime kiln, Continuous gas-fired, Mount .. *428
Linde helium plant at Fort Worth ... *110
Linseed production in Argentina ... 220
Liquefaction of gases. See gases, liquefaction of.
Liquid air plant at Muscle Shoals ... *12
Literature, Chemical, Art of searching, Hibbert ... 581
Litharge, Production in U. S. ... 38
Lubricating oils from coal ... 78

M

Magnesite, Artificial. (P.) ... 248
——Furnace linings. (P.) ... 248
Magnesium, Metallic, Seward. (P.) ... 87
Magnesium oxide from dolomite. (P.) .. 248
Magnetic concentration, Pyrrhotite, Bonardi ... 266
MANGANESE:
——Alloys, Use in open-hearth, Hoyt (N.) 215
——Bronze, Manufacture, McKinney. (N.) ... 212
——Canadian deposits. (N.) ... 263
——Dioxide depolarizers. (P.) ... 432
——Ore, Concentrating, Newton. (N.) ... 211
——Ores, Domestic production ... 581
——Ores, Gold and silver recovery, Carson. (P.) ... 544
——Steel, Nichols. (P.) ... 296
—— Hadfield's ... 618
Manufacturers' Catalogs 48, 144, 200, 256, 304, 368, 448, 552, 608, 656.
Manufacturers' rights, Gudeman. (N.) .. 117
Markets, Non-Ferrous, Iron and Steel and Chemical 42, 91, 137, 194, 250, 298, 362, 441, 489, 545, 602, 649.
Masks, Gas, For industrial use ... 188
——Limitations for industrial use ... 220
——Use in SO_2 industries, Fieldner and Katz ... *582
Mason work at large acid plant ... 411
Matagorda sulphur deposit ... *186
Matte, Nickel-copper, Refining, Sanger. (P.) ... 296
Medicinal compounds, Synthetic, Stieglitz. (N.) ... 115
Meetings and Events, Coming 143, 200, 256, 304, 367, 447, 496, 551, 608, 655.
Melting points of chemical elements ... 351
Mental tests in industry, Yerkes. (N.) .. 210
Merck & Co., Stock to be sold ... 456
MERCURY:
——Fulminate, Proposed substitutes ... 454
——Minor European deposits, Sterner-Rainer ... 82
——Poisoning by ... 83
——Price control of Spanish ... 32
——Losses, in Spanish furnaces ... 34
——Production at Almaden, Spain, Sterner-Rainer ... *32
——Production costs ... 454
——Production statistics, Spain ... 35
Mesothorium as radium substitute ... 168
Metal industry, Report of Alien Property Custodian ... 313
Metall Gesellschaft, Organization ... 314
METAL PROTECTION:
——General:
—— Preparation of surfaces for coating 535
—— Rust-proofing iron and steel, Rawdon, Grossman and Fine ... 458, *539
Bibliography ... 591
—— Salt spray test for coatings ... 462
—— Testing various coatings ... 461
——Coatings:
—— Aluminium ... 459
—— Blue oxide ... 460
—— Brass ... 460
—— Copper ... 460
—— Microstructure of ... *536
—— Copper coatings on steel, Silverman. (N.) ... 211
—— Lead ... 459
—— Nickel and cobalt ... 460
—— Oil coating, Jensen. (P.) ... 487
—— Tin ... 459
—— Zinc ... 459
—— Microstructure of ... *539
METAL PROTECTION—*Continued:*
——Processes:
—— Bower-Barffing ... 460
—— Calorizing ... 459
—— Carbonia process ... 460
—— Coslett process ... 461
—— Electroplating ... 459
—— Epicassit ... 459
—— Etching ... 460
—— Galvanizing ... 459
—— Parker process ... 458
—— Schoop spraying process ... 459
—— Sherardizing ... 459
METALS:
——Brittle, Briquetting, Vogel. (P.) ... 647
——Colloid-chemical nature, Alexander. (N.) ... 212
——Decomposition of, Krynitzky .. *277, *421
——Correction ... 501
——Mechanical properties, Effect of temperature, deformation and grain size on, Jeffries. (N.) ... 211
——Volatile, Refining, Huldt. (P.) ... 487
Mexican claims, Standard forms for ... 453
Mexico, Protection of American rights in. 270
Micrometer, With pressure attachment ... 434
Microscope, Application to ore dressing .. 232
Milling calculations, Lewis ... 224
Mills, Ball, Fine crushing in, Davis. (N.) . 210
——Tube, Calculating tonnage of ... 227
Mineral production, British Columbia, 1918 148
——California, 1918 ... 149
Minerals Relief Commission ... 454
Minerals Separation vs. Butte & Superior. 318
Mining industry, Co-operation, Parmelee. (N.) ... 263
Molasses, Potash from fermentation liquors *55
Molybdenum, Canadian practice, Lamble. (N.) ... 262
——Electrometallurgy of, Escard. (S.) .. 645
Monochlorbenzol, Manufacture at Kingsport ... 640
Mono recorder, CO_2 and CO ... *245
Morterud process of pulp cooking. (N.) . 184
Munitions, Disposition of by War Dept. .. 76
Muscle Shoals Nitrate Plant, Fairlie ... *8
Mustard gas symposium. (N.) ... 393

N

National Advisory Research Council, Canadian. (N.) ... 263
National Foreign Trade Council, Convention ... 136
National Industrial Conference Board, Prize essay contest ... 219
National Research Council, Report of Patent Committee ... 150
National Research Fellowships ... 400
National Service Committee ... 114
Navy Explosives Plant, Sale ... 233
Nevada, Mining schools in ... 148
New Caledonia, Electrometallurgy of nickel ores, Sabathier ... 646
New Cornelia Copper Co., Leaching at. (N.) ... 212
——Report ... 615
NEW JERSEY CHEMICAL SOCIETY:
——December meeting ... 39
——January meeting ... 100
——April meeting, Program ... 334
——Spring meeting, Program ... 456
—— Report ... 562
New Jersey Clay Workers' Association, New Brunswick meeting ... 39
New Jersey Manufacturers' Council Meeting ... 40
New York, American Electrochemical Society meeting ... 379
——American Institute of Mining Engineers. ... *208
——American Welding Society meeting .. 400
——Society of Chemical Industry, April meeting ... 457
Nichols joints, Zinc ... 341
Nickel, Copper matte, Refining, Sanger. (P.) ... 296
—— Haylund, (P.) ... 597
——Electrolytic refining, Guess. (N.) .. 383
—— Haylund, (P.) ... 597
——Electrometallurgy in New Caledonia, Sabathier ... 646
——Sudbury ores. (S.) ... 88
Nickle tangential Dutch oven ... 65
Nicu steel. (S.) ... 88
Nipissing Mines Co., Ltd., Report ... 616
NITRIC ACID:
——Concentration of, Zeisberg. (P.) ... 296
——French production ... 57, 542
——From ammonia, Landis. (P.) ... 431
——From ammonia, Muscle Shoals ... 15
——Plant at Kingsport ... 640
——Plant at Nitro, Hollister ... *406
——Production, 1918 ... *406
Nitro, W. Va., Acid plant, Hollister ... *406
Nitro-glycerine explosives industry ... 311
Nitrobenzol, Manufacture at Kingsport .. 639
Nitro-cellulose, Solvent recovery, Nash. (P.) ... 296
Nitrogen from liquid air, Muscle Shoals . 12
Nitrogen fixation, Government plant at Muscle Shoals ... *8
——Nitrogen from air, Tommasi. (P.) .. 431
——Patents ... 431
——Present status of, White. (N.) .. 115, 117
——Schoenherr furnace, Buffer for La Cour. (P.) ... 596
Nitrosonhenol, Manufacture at Kingsport 639
Nodulizing flotation concentrates in rotary kiln, Draper ... 621
Non-Ferrous Metal Market ... 42, 91, 137, 194, 250, 298, 362, 441, 489, 545, 602, 649.
Norton helium plant at Petrolia ... *110
Norway, Water-power resources. (S.) ... 542
Notch toughness, Hoyt. (N.) ... 213

O

Ohio Copper Mill ... 6
Oil, Flotation, From crude tar ... 341
——Lubricating, From coal ... 79
Oil shales, Present status of ... *28, 204
Open Price Associations ... 121
Ordnance Department, Sale of scrap .. 101, 191
Oregon, Chromite deposits in ... 79
ORES:
——Chloridizing complex ... 207
——Chromite, Concentration of ... 80
——Chromium in California ... 319
——Copper, Ammonia leaching, Eddy .. 328
——Copper, Oxidized, In Arizona ... 559
——Manganese, Concentrating, Newton. (N.) ... 211
——Manganese, Domestic production 581
——Manganese, Gold and silver recovery, Caron. (P.) ... 544
——Manganese in California ... 319
——Mercury, Sorting and sampling ... 33
——Nickel, Electrometallurgy in New Caledonia, Sabathier ... 646
——Pyrrhotite, Magnetic concentration .. 266
——Sintering, Richards. (P.) ... 297
——Sulphur, Novel treatment, Thomas. 261
——Zinc, Electrolytic refining, Gillies. (P.) ... 544
Organic chemistry, Industrial, Future of, Hibbert ... 335
Overheated bearings, Detecting ... 577
Oxidation and reduction, Little. (N) .. 562
Oxygen as a revolutionizer. (S.) ... 541
Oxygen breathing apparatus ... 221
Oxygen, Possibility of cheap production .. 106

P

Pan-American Commercial Conference 375
PAPER:
——Industry, Vocational education in .. 185
——Manufacture at Kingsport ... 643
——Mills, Tannin from waste bark ... 319
——Treatment of waste liquors. (S.).. 542
——Paraffined, Recovering waste ... 483
——Waterproof reinforced ... 90
Paraffin wax, Purifying. (S.) ... 434
Patent Committee, Report of ... 150
Patents, Commercial development of Government employees' ... 105
Patents, Recent Chemical and Metallurgical 86, 248, 296, 431, 487, 544, 596, 647.
Pearlite, Effect of cold working on. (S.).. 192
Penn-Wyoming Copper Co. sold ... 148
Perchloric acid, For cement analysis ... 452
Perkin medal, Award ... *102
Perkin medalists, Classification ... 205
Permeability of concrete tanks ... 234
Perryville, Ammonium nitrate plant at .. *320
Personnel, Classification of, Exhibit ... 319
Petroleum, Asphaltic base acid sludge, Utilization of, Baskerville. (N.) .. 394
——Products from coal ... 7
Phelps-Dodge Corporation, Report ... 616
Phenol, French production ... 58
——Manufacture, Peterkin. (N.) ... 394
Phosphorus, Determination of, in copper alloys ... 58
Photography in research, Eldredge *506
——Johnson ... *612
Phthalic anhydride, New process ... 378
Picric acid plant sold ... 540
Pigment, Zinc, Refining, Wemple. (P.).. 296
Pine-resins, Distillation of, Dunwoody. (P.) ... 297
Pipe bending machine, Portable ... *600
Pittsburgh, American Ceramic Society meeting ... 180
——Electric power developments at ... 31
PLATINUM:
——Black sands contain little ... 101
——Canadian deposits. (N.) ... 263
——Economy in industrial laboratories, Mueser ... 69
——Substitute, Belais. (P.) ... 487
Poisoning, Lead ... 477
——Mercury ... 83
Poland, German requisitions in ... 265
Polytechnic Institute of Brooklyn, Dinner. 505
Porcelain, Dielectric failure of. (N.).... 183
——Physical properties. (N.) ... 183
——Pots, Casting of. (N.) ... 182
Postal zones and rates ... 564
POTASH:
——Blast-furnace, A criticism ... 308
—— Reply ... 373
——Caustic, Manufacture of stick ... 148
——Determination in cement by perchloric acid ... 452
——From cement kiln dust, Anderson. (P.) ... 544
——From iron blast-furnace gases. (P.) 432
——From molasses fermentation liquors, Humboldt ... *55
——From silicates, Sterling. (P.) ... 86
——From wood-ashes ... 461
——Industry, Future of ... 310
——Kelp industry, Collapse of ... 206
——Salts, Separation of, Bassett ... 76
Potassium hydroxide, Manufacture of pure ... 148
Potassium sulphate from alunite, Chappell. (P.) ... 249
Powdered coal. See coal, Powdered.
Power data for electrolytic zinc. Supplement to Feb. 15.

Power, Electric, Production by states 617
Power, Resources, Survey of 151
Precipitators, Electrical. E. E. Thum... *59
Price Associations 121
Producer, Gas, Slagging. (S.)..... 192
Pro patria, pro meter, pro liter..... 31
Publications, New
96, 144, 200, 448, 496, 552, 656.
Pulp, Formulas for water and solid in... 228
Pump selection. Everett 246
Pump, Valveless 599
Pyrometer for brass and bronze 436
Pyrometer tubes, Defects in. (N.)..... 183
Pyrometry symposium, Program 455
Pyroxylin compounds. Lindsay. (P.)..... 296
Pyrrhotite. Magnetic concentration. Boo-
ardi 266
——Smelting copper-nickel. Johnson. (P.) 86

Q

Quicksilver (see mercury).

R

Railroad research work 558
Rails, Transverse fissure investigation.
Comstock. (N.) 214
——Zinc for bonding 341
Ramsay Memorial Fund in America..... 64
Raymond, Dr. Rossiter W., Obituary.... *54
Reagent, Reducing. Bradley. (P.)..... 86
Recent Chemical and Metallurgical Patents
86, 248, 296, 431, 487, 544, 596, 647.

RECORDERS:
——Carbon Dioxide:
—— Types, uses of, etc. Kershaw.. *176,
*241, *291
—— Arndt *291
—— Auto *243
—— Bi-meter *243
—— Cambridge bi-meter *243
—— Haber-Loewe *292
—— Krell *291
—— Mono *245
—— Sarco *241
—— Simmance-Abady *243
—— Telezometer *291
—— Thermoscope *291
—— Uehling *242
—— Webster, W. R., Combustion indica-
tor *245
——Miscellaneous:
Hydrogen mono *191
Rectifiers, Mechanical, For Cottrell proc-
ess 61
Red Cross Institute for Crippled and Dis-
abled Men 416
Red lead, Analysis of. Edwards..... 35, 260
——Production of in U. S..... 38
Reducing reagent. Bradley. (P.)..... 86
Refractometer. Haber-Loewe *292
Refractories, Basic, Open hearth. (N.).. 213
——Magnesian. (P.) 248
Refractory materials, Influence of temper-
ature on slag action. Howe..... 167
Reinforced concrete tanks. Frerichs.... 234
Research Corporation, Object of 103
Research Fellowships, National 400
——University of Idaho 528
Research, Industrial, in England 399
Research, Photography in. Eldredge *506
—— Johnson *612
Research, Steel, Laboratory 615
Research vacancies, Univ. of Ill. 151
Resilometer 434
Resins, Crude pine, Distillation of. Dun-
woody. (P.) 297
Respirators, Limitations of 220
Roofing, Bituminous. Wilson 425, 484

RUBBER:
——Accelerators, Organic vs. inorganic.. 417
——Substitutes. Dannerth. (N.) 100
——Tires, Solid. King *352
——Vulcanized. Effect of accelerators on
properties. Kratz and Flower... 417
——Vulcanization, Effect of accelerators.
Kratz. (N.) 100
Russia, Copper smelter equipment. Car-
lyle. (N.) 263
Rust-proofing. See metal protection.

S

Sagger mixtures. Brown. (N.) 39
Saggers, Improved. Tone. (P.) 597
Salvaging industrial casualties. McMur-
trie 415
Sampler, Continuous, For sulphuric acid.. 38
——Flue gas, Automatic *291
Sandstone, Asphaltic, Extraction of kero-
gens from 31
Sarco CO_2 recorder *241
Schoellkopf plant, A. C. S. visit..... 395
Scholarships, Chemists' Club 620
——Johns Hopkins 564
Schools, Mining, Nevada 148
Screening efficiency, Calculation of..... 227
Sea water, Corrosion of brass in. Bruhl.. 239
Seaweed Iodine from. Bredenburg. (P.) 487
Sewage, Cost of sterilization by chlorine.. 414
Sewer pipe, Manufacture at Kingsport... 568
Shales, Oil-bearing, Distillation of..... *39
——Present status of *28, 204
Sheffield Ala., Nitrate plant at..... *8
Shells, Heat-treating. Hall. (S.)..... 193
——Criticism 374
——Lead plating. Reeve. (N.) 388
Shirmer case-hardening process. Richards.
(N.) 213
Silicates, Potash from, Sterling. (P.).. 86
Silicol process, Hydrogen *289
Silicon alloys, Hydrogen from..... *289
Silicon chloride, Smoke screens. Richter.
(N.) 386
Silicomanganese. Klugh. (N.)..... 388
Silver, Production, 1918 188
——Refining, Moebius. Griswold, (N.).. 382
——Removal of export restrictions 528
Silver chloride, Colloidal. Wood 260
Simmance-Abady CO_2 recorder *243
Sintering ores. Richards. (P.) 297
Sintering zinc residues. Stock *525
Slag, Action upon refractories. Howe... 167
——Analyses of typical 167
——Blast-furnace. Cement from..... 25
——High-phosphorus. Walker. (P)..... 647
——Inclusions as cause of flakes. Styri
*343, 478
—— Correction *453
Slagging gas producer. (S.)..... 192
Sluices, Formulas for 230
Smelting copper-nickel pyrrhotite. John-
son. (P.) 86
Smoke dissipation, High stacks for..... 311
Smoke screens. Hutchins. (N.) 386
Society of Chemical Industry, New York
meeting, April 457
Soda liquors, Treatment of. (S.)..... 542
Sodium chloride, Effect on blue-powder
formation. Dean 628
Sodium cyanide, Separation from hydrox-
ide. Metzger. (P.) 431
Sodium nitrate, Disposal of by Gov't.... 236
Sodium permanganate, Electrolytic. (N.). 387
Sodium silicate, silicol process *289

SPECIFICATIONS:
——Acetic anhydride 540
——Acetone, Commercial 540
——Ammonium chloride 540
——Bituminous roofing materials 486
——Carbon, tetrachloride 540
——Glue, Liquid 430
——Leather belting. (S.)..... 543
——Locomotive crane parts. (S.)..... 433
——Napthalene 540
——Potassium permanganate, Commercial 540
——Rubber tires, Solid 358
——Sodium cyanide 540
——Steel for machine parts..... 519
——Tannic acid, Commercial 540
——Zinc coatings on iron..... 464
Specific heat, Silicates and platinum. (S.) 434
Speed reducer, Spur gear *648
Stacks, High, For smoke dissipation..... 311
Standard temperatures 351
Steam, Exhaust, at high back pressures.
Field 18
Steel, see also Iron and steel.
——Flaky and woody. Giolitti..... *271
——Helmets and armor. Coyle..... 618
——Research laboratory 615
——Wheels, Dayton one-piece..... *190
Stocks and Bonds
200, 256, 304, 368, 448, 496, 552, 608, 656.
Storage tanks, Concrete. Frerichs..... 234
Sugar, Beet, Production in Utah and Idaho 560
Sulphidizing process 169
Sulphidizing by roasting. Dwight. (P.). 297
Sulphidizing lead ores. Allen..... 169
Sulphite liquors, Treatment of. (S.).... 542
Sulphonic acids, Aromatic. (P.)..... 596
——New 282
——Patent 596
Sulphur, Burner, Downdraft, McIntyre. (P.) 647
——Frasch patents, Court decision. Mock
and Blum 637
——Fraschman passes. Foster. (P.)..... 545
——New mine in Texas..... *186
——Ore, Novel treatment. Thomas..... 261
Sulphur dioxide, Army gas masks for use
with. Feldner and Katz..... *582
——Determination. (S.)..... 541
——Physiological effects 582
——Production McIntyre. (P) 647
Sulphur dyes, Manufacture at Kingsport.. 639

SULPHURIC ACID:
——Continuous sampler for..... 38
——French production 57 542
——Fuming, Action on cast iron. (S.).. 433
——Plant at Nitro. Hollister..... *406
Surface combustion, Roasting by. Mc-
Court. (P.) 297
Sweden, Exchange of scholarships with.. 505
Synopsis of Recent Chemical and Metallur-
gical Literature
88, 135, 192, 433, 541, 594, 645.

T

Tanks, Reinforced concrete, Frerichs..... 234
Tannery at Kingsport 641
Tannin, From waste paper-mill bark..... 319
Tanning extract plant at Kingsport..... 641
Tar, Continuous distillation of 524
Tar, Hardwood, Flotation oils from...341, 586
Technical Association of Pulp and Paper
Industry, New York Meeting..... *184
——Spring meeting, Erie, Announcement. 505
Telezometer *291
Temperature, Effect on mechanical proper-
ties of metals. Jeffries. (N.)..... 211
——Influence of, on slag action on re-
fractories. Howe 167
——Observations on heating of large steel
forging. Knight and Hansen..... 590
——Standards 351
——Uniformity, Electric furnace. Fergu-
son 283
Texas Gulf Sulphur Co. *186
Text-books, Common errors in chemical.
Smith. (N.) 39
Thermoscope. For CO_2 ..... *291
Thorium compounds. Clarke. (P.)..... 487

TIN:
——Allotropic modifications *277
——Effect of decomposition of aluminium
alloys 423
——Import restrictions removed 638
——Situation, Summary of 231
Tires, Solid Rubber. King *352
Toluol, French production 57
Tools, Davidson casting process. Johnson.
(N.) 213
Tomboy Gold Mines Co., Report..... 149
Trade, Foreign, Aids to..... 189
Trade resumption with Europe..... 389
Trailer, Trackless 437
Trinitrotoluol, Use for surplus..... 455
Tubes, Corrosion of condenser. (S.)..... 594
Tungsten in England. (S.)..... 595
——Oxide, Reduction of. Orance. (P.) 597
Tunnel kiln, Types of. (N.)..... 39

U

Uehling gas compositometer..... *242

UNITED STATES:
——Ammonium nitrate plant..... *320
——Employment service, Work of..... 270
——Nitrate Plant No. 2, Fairlie..... *8
——Nitrate Plant No. 2..... *8
——Gold production, 1918..... 188
——Lead pigment production in..... 38
——Manganese ore production..... 581
——Silver production, 1918..... 188
——Tariff Commission, Proposed dyestuffs
amendments 70, 116
University of Idaho, Research fellowships 528
University of Illinois, Research vacancies. 151
Uranium from pitchblende, Carbide
method. (N.) 382
U. S. Smelting, Refining and Mining Co.,
Report 616

V

Vacuum drum drier..... *642
Valve, Gas reversing 435
Vanadinite, Vanadium and lead from,
Conley. 514
Vanadium, From euprodescloizite, Conley 465
——From vanadinite, Conley 514
——Methods of extraction..... 466
Vancouver, Mining conference 454
Vogelstein, L., & Co., Organization..... 315

W

War minerals, Commission to settle losses
on 327
War-time trip to Europe, Parmelee..... *124
War Trade Board Rulings
100, 154, 188, 189, 319, 389, 424, 638.
Waste, Principles of, Steinmetz. (N.).. 184
Waste liquors from paper mills, Treat-
ment. (S.) 542
Waste, Steel works and industrial, Hall.. 327
Water glass, see sodium silicate.
Water power, Bill, Fate of..... 265
——Government ownership. (N.)..... 380
——Legislation 151
——Legislation needed 415
——Resources in Norway. (S.)..... 542
Waterproofing, Aëroplane propellors 175
——Concrete 223
Waterproof paper 90
Water-resistant glues 601
Wax, Paraffine, Purification of..... 434
Webb Law 120
Webster W. R. combustion indicator..... *245
Welder, Portable electric arc..... 436
Western Chemical and Metallurgical Field
6, 55, 148, 206, 375, 454, 559, 613.
Wheels, Steel, One-piece..... *190
White lead, Production in U. S..... 38
Women, Susceptibility to lead poisoning.. 477
Wood Acetic acid from..... 185
——Acetone from, Bassett 190
——Alcohol from 185
Wooden boxes, Metal strapping on..... 483

Z

ZINC:
——Alloys with copper and aluminium,
Guillet and Bernard 645
——Alloys with iron 530
——Coatings on iron and steel, Metal-
lography 530
——Distillation, Berglund. (P.)..... 487
——Dust, Newell. (P.)..... 544
——Effect of sodium chloride on blue-
powder formation, Dean 628
——Electrolytic From acid chamber
sludge. Broughton *155
——Electrolytic, Power Data, Clevenger
and Mulock. Supplement to Feb. 15.
——Electrolytic refining, Gillies. (P.) 544
——Government spelter disposal..... 424
——Industry, Economics of, Choate..... 237
——Industry, Economics 260, 500
——Leaching, Sulman and Picard. (P) 647
——Pigment Refining, Wemple. (P.).. 296
——Price adjustment at Joplin 6
——Residues Sintering, Stock..... *525
——Rail bonding 341
——Smelting, Sulphides pass directly to
oxides 500
——Working conditions in gas belt
smelters 375

AUTHORS' INDEX

ALLEN, GLENN L. Flotation of oxidized ores of lead 169

BACHARACH, HERMAN. Determining zero reading on an Ellison gage. 246
Baker, R. E. Large vs. small electric furnaces 374
Balcom, A. R. Ferromanganese 52
Barrett, J. C. Cleaning furnace gases without the use of water 359
Bassett, H. P. Acetone 190
———Separation of potash salts 70
Boreslavsky, Euphime. Influence of gypsum on the blast-furnace slags in the manufacture of cement 25
Blum, Asher and Hugo Mock. Decision on Frasch patents on sulphur mining 637
Bolling, J. Esten. Effecting and controlling crystallization of ammonium nitrate 401
Bonardi, J. P. Magnetic concentration of pyrrhotite ores 266
Booth, William Miller. A great opportunity for the intelligent location of industries 311
Broughton, H. E. Electrolytic deposition of zinc 155
Bruhl, Paul T. Corrosion of brass in sea water 239

CHANDLER, C. F. Perkin Medal presentation address 102
Choate, Parker C. Economies of the zinc industry: A prophetic discussion 237
Clevenger, G. H. and F. S. Mulock. Power data for electrolytic zinc. (Supplement, Feb. 15, 1919.)
Coghill, Will H. Hand device for flotation experiments 537
Cohoe, Wallace P. Chemical specifications 539
Comstock, George F. An example of crystal crushing 309
Conley, J. E. A proposed metallurgical process for the treatment of vanadinite for the recovery of lead and vanadium 514
———Treatment of cuprodescloizite for extraction and recovery of vanadium, lead and copper 465
Corse, W. M. The aluminium bronze industry 163
Cottrell, Frederick G. Commercial production of helium 104
Coyle John A. Alloy steels for helmets and armor 618
Croasdale, Stuart. High stacks for smoke dissipation 311

DEAN, REGINALD S. The Bradford process of preferential flotation. 372
———Effect of sodium chloride on blue-powder formation 628
Draper, Robert M. Nodulizing flotation concentrates in a rotary kiln with powdered coal 621
Driscoll, R. A. That missing page from the blue-back speller 53

EDDY, LAWRENCE. Practical considerations in ammonia leaching of copper-bearing ores 328
Edwards, W. F. The analysis of red lead 260
———Notes on the chemical analysis of red lead 35
Eldredge, Arthur G. Photography in research 506
Everett, B. N. Points in pump selection. 246

FAIRLIE, ANDREW M. Muscle Shoals nitrate plant 8
Foild, Alex. L. Flaky structures and their possible elimination 556
Ferguson, John B. Temperature uniformity in an electric furnace 283
Field, Crosby. Engineering research in chemical precautions 84
———Exhaust steam at high back pressures 18
Fieldner, A. C., W. A. Selvig and W. C. Ratliff. Fusibility of coal ash. 274
———and S. H. Katz. Use of army gas masks in atmospheres containing sulphur dioxide 582
———and W. A. Selvig. Fusibility of ash from Pennsylvania coals 629
Finn, A. N., Henry S. Rawdon and M. A. Grossman. Metallic coatings for rust-proofing iron and steel—I 458
II 530
III 591
Flower, A. H. and G. D. Kratz. Effect of certain accelerators upon the properties of vulcanized rubber. 417
Frerichs, F. W. Storage tanks made of reinforced concrete 234

GELLERT, N. H. Potash recovery 308
Gerner, George C. and Arthur Phillips. Notes on the influence of certain variables associated with the anneal of cold-worked alpha brass 622
Giolitti, Dr. Federico. Observations on flaky and woody steel 271
Grasty, J. S. Recovery of potash 373
Grigioni, J. L. Instituto Cientifico Industrial del Salitre de Chile ... 205
Grossman, M. A., Henry S. Rawdon and A. N. Finn. Metallic coatings for rust-proofing iron and steel—I 458
II 530
III 591
Grugan, Justice F. Chrome sands on the Pacific Coast 79

HALL, FRANCIS. Reclaiming steel works and industrial wastes 326
Hansen, F. F. and O. A. Knight. Temperature observations on heating, quenching and drawing of a large steel forging 590
Hawley, L. F. and O. C. Ralston. Flotation experiments on hardwood tar oils 586
Hayward, Carle R. Laboratory electrodeposition plant 240
Hayward, R. A. Fundamental principles to be considered in the heat treatment of steel 519
Hendrick, Ellwood. Chemical warfare—A new weapon 152
Hesse, Bernhard C. The American chemists' responsibility 559
Hibbert, Harold. The art of searching chemical literature 557, 578
———Future of industrial organic chemistry 335
Hobsbawn, J. Berkwood. Instituto Cientifico Industrial del Salitre de Chile 205
Hollister, H. E. and C. E. Erection of huge sulphuric, nitric, mixed acid and denitrating plant under war pressure 406
Howe, H. M. That missing page from the blue-back speller 501
Howe, Raymond M. Influence of temperature upon the action of slag upon refractory materials 167
Humboldt, E. Recovery of potash from molasses fermentation liquors .. 55

IONIDES, S. A. Continuous sulphuric acid sampler 38

JACKSON, LUIS. Railroad research work 558
Jacoby, Henry E. Centrifugal agitator and distributor 598
Johnson, Charles Morris. Determination of uranium, zirconium, chromium, vanadium and aluminium in steel—I 523
II 588
Johnson, E. M. Economics in the zinc industry 500
Johnson, Nathan C. Photography in research 612

KATZ, S. H. and A. C. FIELDNER. Use of army gas masks in atmospheres containing sulphur dioxide 582
Kershaw, John B. C. Fuel economy in the boiler house—I 176
II 241
III 291
King, Andrew H. Solid rubber tires ... 352
Knight, O. A. and F. F. Hansen. Temperature observations on heating, quenching and drawing of a large steel forging 590
Kratz, G. D. and A. H. Flower. Effect of certain accelerations upon the properties of vulcanized rubber. 417
Krynitzky, Col. A. I. Decomposition of metals — I 277
II 421
(Correction) 501

LANDIS, W. S. The oxidation of ammonia 470
Lewis, Robert S. Milling calculations .. 224
Lonergan, Jay. Eliminating phosphorus and sulphur in electric ferromanganese furnaces 245
Lovejoy, C. H. Improved form of granular carbon resistance furnace for fusion point of coal ash and firebrick 538

MCMURTRIE, DOUGLAS C. Salvaging industrial casualties 415
Maoussa, Georges. Industrial efforts in France during the war 56
Mardick, J. R. Application of nitro-aromatic compounds in explosives industry 311
Merten, W. J. Heat treating of shells .. 374
Meyer, A. L. That missing page from the blue-back speller 612
Miller, L. F. Modification of the cyanide method for the estimation of nickel in steels 613
Mock, Hugo and Asher Blum. Decision on Frasch patents on sulphur mining 637
Morey, George W. An improved method of optical glass manufacture ... 511
Moses, Frederick G. Flotation for the practical mill man 571
Mount, W. D. Burning lime in a gas-fired continuous kiln 428
Mueser, E. C. Platinum economy in the industrial chemical laboratory .. 69
Mulock, F. S. and G. H. Clevenger. Power data for electrolytic zinc. (Supplement, Feb. 15, 1919.)

NEWBERRY, WILLIAM B. The perchloric acid method for potash in cement materials 452
Nickle, Frank H. Furnace settings for caustic pots 65, 261

OSSA, BELISARIO DIAZ. Instituto Cientifico Industrial del Salitre de Chile 205

PARMELEE, H. C. Notes on a war-time trip to Europe 124
Pearce, Jackson A. Colloids in flotation. 52
Pelton, H. A. and M. W. Schwarz. The manufacture of hydrocyanic acid 165
Petzold, Fred. Credit to whom credit is due 453
Phillips, Arthur and George C. Gerner. Notes on the influence of certain variables associated with the anneal of cold-worked alpha brass 622
Place, Richard G. Rapid electrolytic copper assay without rotating cathode 452

RALSTON, O. C. and L. F. HAWLEY. Flotation experiments on hardwood tar oils 586
Ratliff, W. C., W. A. Selvig and A. C. Fieldner. Fusibility of coal ash 274
Rawdon, Henry S., M. A. Grossman and A. N. Finn. Metallic coatings for rust-proofing iron and steel—I 458
II 530
III 591
Rollin, William H. Future of the barium industry 163

SCHWARZ, M. W. and H. A. PELTON. The manufacture of hydrocyanic acid 165
Selvig, W. A., W. C. Ratliff and A. C. Fieldner. Fusibility of coal ash 274
———and A. C. Fieldner. Fusibility of ash from Pennsylvania coals ... 629
Simpson, Louis. The present status of oil shales 204
Sosman, Robert B. Bucher cyanide process 559
Sterner-Rainer, Dr. Roland. Mercury production at Almaden, Spain 32
———Minor occurrences of mercury in Europe 82
Stock, K. Sintering zinc residues 525
Stoughton, Bradley. Joseph Earey Johnson, Jr. 376
Stratton, S. W. Work of the Bureau of Standards on electroplating 501
Strong, R. K. Classifying the Perkin medalists 205
Styri, Haakon. Flakes in steel 453
———Flaky fractures and their possible elimination 556
———Observations on so-called "Flakes" in steel 342

TAYLOR, L. R. Analysis of ferromanganese 53
Thomas, Kirby. Novel method for treating sulphur ore 261
Thompson, G. W. Our chemical industries made permanent 118
Thum, Ernest Edgar. Notes on electrical precipitators 59
Toch, Maximilian. Concrete as a chemical engineering material 222
Tone, F. J. Electrochemistry in its human relations 413
Turnbull, Robert. Electric pig iron after the war 178
Turrentine, J. W. Future of the potash industry 310

VOM BAUR, C. H. Vom Baur electric furnace 488

WILSON, GEORGE LANDIS. Bituminous roofing materials and construction — I 425
II 484
Wesson, David. Some wild engineering I have known 512
Wood, R. F. Colloidal condition of silver chloride 260

Published SEMI-MONTHLY *on the* FIRST *and* FIFTEENTH *of each month*

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

McGRAW-HILL COMPANY, INC.

Tenth Avenue at 36th Street

NEW YORK

JAMES H. McGRAW, President
ARTHUR J. BALDWIN, Vice President E. J. MEHREN, Vice President
EDWARD CALDWELL, Treasurer JAMES H. McGRAW, Jr., Secretary

TELEPHONE 2840 Greeley CABLE ADDRESS, Machinist, New York

WASHINGTON, 1410 H. St., N.W. SALT LAKE CITY, Newhouse Bldg.
CHICAGO, Old Colony Bldg. PHILADELPHIA, Real Estate Trust Bldg.
CLEVELAND, Leader-News Bldg. SAN FRANCISCO, Rialto Bldg.
LONDON, 6 Bouverie St., E. C. 4.

H. C. PARMELEE, Editor
ELLWOOD HENDRICK, Consulting Editor
ERNEST E. TRUM, Western Editor
WALLACE SAVAGE, Assistant Editor

J. MALCOLM MUIR, General Manager

Yearly Subscription price for United States, Mexico and United States dependencies, $3; all other countries, $4. Single Copy, 25c.

When change of address is ordered, the NEW and the OLD addresses must be given. Notice must be received at least 10 days before change takes place. No back copies for more than three months.

Copyright, McGraw-Hill Co., Inc., 1918. Entered as Second-Class Matter at the Post Office at New York, N. Y., July 13, 1918, under the Act of Congress of March 3, 1879

Circulation of this issue 11,350 *copies*

CONTENTS *for* January 1, 1919

Volume 20, *Number* 1

EDITORIAL

Pan American Engineering Literature..... 1
The Gold Producer and Political Economist..... 1
An Engineering Opportunity—The By-Product Coke Oven.. 2
The Metallurgy of Copper in 1918..... 4
Iron and Steel in Last Year of War..... 5
Western Chemical and Metallurgical Field..... 6
Muscle Shoals Nitrate Plant. By *Andrew M. Fairlie*..... 8
Exhaust Steam at High Back Pressures. By *Crosby Field*....18
Influence of Gypsum on the Blast Furnace Slag in the Manufacture of Cement. By *Euphime Bereslavsky*.....25
The Present Status of Oil Shales.....28
Power at Pittsburgh.....31
Pro Patria, Pro Meter, Pro Liter.....31
Mercury Production at Almaden, Spain. By *Dr. Roland Sterner-Rainer*.....32
Notes on the Chemical Analysis of Red Lead. By *W. F. Edwards*.....35
Institute of Chemical Engineers.....37
Census of Chemical Imports.....38
Production of Lead Pigment in the U. S.....38
Continuous Sulphuric Acid Sampler.....38
New Jersey Clay Workers Association Holds Meeting.....39
New Jersey Chemical Society.....39
Meeting of Manufacturers' Council of New Jersey.....40
Personals.....41
Obituary.....41
Current Market Reports—Iron and Steel Market, Chemical Market, and Non-Ferrous Metal Market and Chemical Price List.....42
Industrial—Plant Construction, Catalogs and New Publications.47

Pan American Engineering Literature

LA INGENIERIA INTERNACIONAL, the tenth member of our family of engineering magazines, will soon be issued in the Spanish language under the combined efforts of the McGraw-Hill editorial and engineering staffs. We of the chemical and metallurgical realm have especially wished to meet, understand and have greater communication with our neighbors to the South. While it is a fact that CHEM. & MET. has many readers at present in South and Central America, the Philippines and Spain, nevertheless the only efficient way of immediately realizing the much talked of Pan American Union in the engineering field is to break all fetters of speech and print in the most convenient language for our readers. For four and a quarter centuries, Spanish navigators have planted their language in many large but dispersed parts of the world. The general demand for a high class united engineering periodical adapted to these rapidly developing countries has not been met. It is believed that the efforts of the thousand specialists in engineering and publication work now united in the McGraw-Hill Company will be of service to these great peoples.

The Gold Producer and Political Economist

WE HAVE sometimes speculated, as we have perused the technical journals of the year just past, as to how their contents will impress the historian who, fifty years hence, may be inquiring into the state of the art of the metallurgy of gold during 1918. We wonder whether he will conclude that the metallurgists of this day were all political economists or whether all our political economists were metallurgists. Perhaps his verdict may simply be that the pressure of war conditions had gone to our heads.

The gold industry has not been on a normal basis for some years. There is no doubt that it has been seriously ill during the past year, and that the illness is continuing. But if a patient's chance of recovery is determined by the number of physicians in attendance, we may predict a speedy cure. Everywhere the situation has been discussed by congresses, conventions, mass-meetings; the technical press has overflowed with articles on the subject, written by mine-owners, mine-managers, metallurgists, geologists—even editors; the remedy was to be found in bonuses, subsidies, tax-exemptions either direct or indirect. It has all been interesting—certainly; instructive—perhaps. But it has added nothing to the metallurgical achievements of the year.

Unquestionably the metallurgical development of first importance has been Crowe's process of precipitation

in vacuo. A process of pleasing simplicity—and simplicity has characterized most of the valuable inventions—it takes a step which, though clearly indicated years ago by the trend of minor improvements, nevertheless escaped the attention of other metallurgists. The elimination of oxygen from the solutions at the approximate moment of precipitation is readily accomplished. The necessary apparatus is inexpensive and the power consumption almost negligible. The resulting saving of precipitant may be, we are informed, as much as 30 per cent.

But the various steps in the cyanide process are so inter-related that the possibilities resulting from the application of this process do not stop here. Thus, as the reduced amount of precipitant naturally leads to improvement in the grade of precipitate, we may speculate as to the probable evolution of refining methods. As we suggested a year ago, the electric furnace may appear in regular practice as a result of these changed conditions; on the other hand, the possible revivification of refining by distillation and recovery of the zinc from the precipitate seems more remote.

Again, although the process benefits in a measure both zinc-dust and zinc-shaving precipitation, its effect will be to improve the relative position of the former in popular favor. Ten years ago the dust method failed of establishment in South Africa, primarily because it could not, in the then state of the art, compete with shavings in the precipitation of a very dilute solution. It seems possible that, reinforced by the Crowe process, a different verdict will be given if the case is reopened.

This, too, is rendered more likely by the continuing development of American zinc-dusts of superior quality. Several such dusts, regularly marketed to-day, are consistently better than the best Silesian dust of 1914 and earlier. Here is one permanent gain for American industry.

Almost simultaneous with the advance in zinc-dust precipitation in America has been a successful development of charcoal precipitation by EDMANDS and MOORE, at the Yuanmi plant in Australia. The precipitating action of various forms of carbon has been for many years a subject of discussion, and we believe it to be the generally accepted conclusion that the actual work of precipitation is done, not by the carbon directly, but by adsorbed gases. This view is supported by the fact that graphite is without action. The very recent campaign for peach-pits and similar shells of vegetable origin, to be converted into charcoal for use in gas-masks, is an interesting illustration of the variation of this property in different charcoals. In the discussion of EDMANDS' paper before the Institution of Mining and Metallurgy, this question was touched upon, and it was emphasized that the successful work at the Yuanmi might have been due, in a measure at least, to the use of charcoal made from mulga—an Australian hardwood.

The precipitating action of certain carbonaceous rocks has often been a source of difficulty in cyaniding, preventing satisfactory extractions through the premature precipitation of some dissolved gold. Work by FELDTMANN and WARTENWEILER on West African ores has shown that such gold may be redissolved in sodium sulphide solutions, and an ingenious process has applied this principle. It seems to have possibilities in other localities.

The special applications of cyaniding to silver ores have experienced no additions during the year, but the work being done in Colorado, under the direction of the Bureau of Mines, will be awaited with interest. This investigation looks to the beneficiation of the manganese-silver ores, so frequent in occurrence and so generally refractory, and we understand that it offers excellent promise.

Flotation, as affecting gold and silver metallurgy, remains as it was a year ago. Mechanically, too, the year has little to record. Practically no new construction has been coming forward, and no new light has been thrown on the crushing problem. BLOMFIELD published an able paper in discussion of Golden Cycle milling, and the data given of the performance of the bowl classifier—the latest of the Dorr machines—suggest that it will have a considerable field of usefulness.

The cyanider is interested in the future of the great nitrogen-fixation plants proposed for war purposes. He is looking to these, and perhaps also to the more serious efforts to produce cyanide from cynanamide, for a considerable reduction in the price of cyanide and for a little healthy competition in the business.

An Engineering Opportunity— The By-Product Coke Oven

THE chance to note the possible improvements in chemical engineering were never greater than at present. Of course, most of us think first of the opportunities naturally furnished or suggested by the sudden change from war to peace—military peace—though it is possible that commercial war of natural competition will be more strenuous than ever.

Among the matters of first importance are the ever vital questions of power and fuel; for, as FRANCIS BACON observed, with his marvelous insight, "As the soul is the former of forms and as the hand is the instrument of instruments, so fire is the helper of helps." PROMETHEUS was well called the friend of man, when he is feigned as bringing down fire from heaven to give to humanity; and well might JOVE himself be jealous of this incomparable gift to his creatures. But it is surprising that we of the twentieth century should be so backward in using and applying this "helper of helps" with so little efficiency and economy.

Among the great developments of the age there may be well counted the "by-product coke" industry. There are several makers of plants that are gradually but surely replacing the old emergency "beehive ovens," which in all candor were devised solely for the purpose of making coke. The iron and steel industry must have coke, and the beehive furnished it; and to the beehive must be given the credit of building up the iron and steel business.

But with the advent of the varied savings of the by-product oven the question still comes up: Why do not the designing engineers go further and study the actual conditions of the by-product process, with its marvelous production and with its marvelous waste? Let us look at it broadly.

It is now a fact, practically recognized by most of the leading gas engineers, that the carbonizing of coal to coke is a process in itself, which, when the coking temperature once is reached and maintained, ought to go on of itself, as though it were almost neutral in its

heat absorption or possibly actually exothermic. This means that, when the coking temperature is once reached, the process ought to go on with the expenditure of no more heat; it ought to be practically automatic. But what do we actually see?

The facts are that the ordinary by-product oven is a gas machine that uses half of the gas produced to maintain the process; that the huge mass of ovens and retorts, with their heating chambers and regenerators or recuperators, is one big, wasteful heat-radiator—and a very wasteful radiator. One cannot step close to the oven pile with any comfort. It is simply one big heat sieve, throwing off good energy—up the stack, and out at the sides, and in all directions. Moreover, the time element is something that is but poorly camouflaged under the enormous profit-and-loss account that seems to carry the whole scheme—the time lost is something that the twentieth century engineer would shudder at if it were put up to him for a first consideration; and we are forced to the conclusion of the farmer who settled all questions of farm economy by saying, "What's the use of time to a hog?"

This wasteful heat-hog of the by-product oven must have come from some such origin as the Hunnish character of some of the names suggest. No Yankee would ever have dared to try to put any such thing across. Only a so-called civilization that was reckless of the time element would ever have had the gall to plan for a carbonization process that takes the best part of a day to coke one oven; and the trick of merely multiplying this by "*x*" or "*n*"—this does not excuse the monumental blunder of the first design, nor its subsequent foisting off on the American public. The only wonder of it all is that it ever happened. It looks as though some of us ought not to be allowed to run around loose without a guardian to watch us and to see that we did not take up with the first "gold brick" that was offered us.

And let us see wherein this wasteful process is wasteful. Here let us notice that the by-product process in general is one of marvelous perfection of well planned detail, so marvelous in its exactly calculated wealth of detail that it is itself a wonder of invention. This well planned process is apparently carefully designed; but it is designed on the wrong plan. It reminds us of the wonderful design that Mother Nature showed when she spent so much time and effort on making the insect creation—a creation that came near rivaling the mental and physical powers of man, but it was designed on the wrong anatomical plan. So of the by-product plan; it is wrong in one—one at least—small feature; that is the heating wall of the oven where the carbonization is done. This heating wall is composed of bricks or the equivalent, which will convey the heat through the wall —in time, that is, the best part of a day.

Think of it! Trying to force the heat necessary to carbonize the coal to coke—and it cannot be great—through some six or eight inches of earthy material. For, to illustrate the case of one of the better grade of ovens, the walls are composed of silica brick six or eight inches long; and the heat must travel endwise through the entire length of the brick to reach the coal. It is no wonder that this heat-conduction process must take nearly a day. It is here that the inventor has a chance to improve on the silica-brick heat-conductor.

To be sure, it is well known that the heat-conductivity of the silica brick is considerably greater than the conductivity of the fire-clay brick that were used for the oven walls earlier; but that does not evade the main question of the time loss of the general process. Neither does the contention of some of the engineers answer the time-loss matter; in that the heat-conductivity of the coal and coke in the inside of the oven is stated to be so slow that the slow heat-conduction of the silica-brick walls can keep up with it.

The facts of the heat-conductivity of the coal or coke in the inside of the oven are not well worked up; but the best authority on the subject tells us that there is no doubt that the heat-conductivity of the coal or coke is immensely greater than the heat-conductivity of the silica-brick walls; though one must consider the heat-insulating power of the porosity of the coal or coke, this latter element causing the heat-conductivity to be retarded about in direct ratio to the porosity. But even then it is fair to assume that the practical heat-conductivity of the average coal or coke must be immensely greater than what it utilized.

There is a strong suspicion that the attempt of some of the gas engineers to cover up this point indicates that they are gradually becoming aware that there is something fundamentally wrong with the design of the by-product coke oven. Moreover, the very necessity of driving the heat-conduction of the silica walls of the oven is so strenuous that the whole process is conducted at temperatures much greater than are necessary for the carbonization of coal to coke. To be sure, the quality of the coke produced—and it must be noted that the purpose of the by-product coke oven is in the first place, generally, the making of coke—is said to be better and more uniform than that of the usual beehive oven; but this is the natural result perhaps of the great care and attention that have been given to this phase of the process. It does not follow that it is impossible to make good coke at lower temperatures or in shorter time.

But the main thing to note is that it ought to be possible to find some material of better, much better, heat-conducting power for the oven wall, that shall replace the silica brick, with its sluggish time factor. Some of us think that we have found some such substitute. The matter is being aimed at, and in due time will be developed; but the wonder is that this marvelous opportunity should not have been studied long ago. The wonder is that such a peculiar case of wrong invention as the silica brick, for this purpose, should ever have had its day. To be sure, it is just like the history of invention that such experiences should happen; but once the matter is brought out into the light it ought to be a plain case of improving it.

Of course, the secret files of many of the large companies might be able to disclose many interesting facts; and we may, in time, find out why this case has been allowed to lie dormant. It is suggestive and will prove interesting matter for the later historian of chemical and metallurgical progress. It may well be that the apparent facts of the case are opposed to any revolutionary changes; it may well be that some fool inventor may find the solution, just because he did not happen to know that the desired improvement is impossible, and so simply may go ahead and find what we are looking for. But whatever the issue of the case, the general

question is worth while studying; for it is patent that we must soon find a more economical method of making gas in such quantities as has not yet been dreamed of. For instance, it ought to be possible to plan for the day when no solid fuel shall be carried into such a congested place as Manhattan Island, for instance; but when all the fuel shall be piped over as gas, or, better, as electricity. It ought to be possible for the time to come when no coal shall be carried from the mine, but when it shall be turned into gas (or electricity) directly at the mine mouth. Such dreams are only the precursor of the reality; for, other things being equal, whatever is rationally thinkable, that is mechanically possible.

Meanwhile, of course, there are possible ways of saving much of the heat now wasted, from the constant radiation in all directions, from such heated masses as by-product ovens, glass pots and the like. It ought to be possible to recover much of this waste by a simple regenerator jacket about the mass, or about its most exposed parts; but the main suggestion is worth pondering; it will arrive in due time, with full realization.

The Metallurgy of Copper in 1918

COPPER production in the United States, steadily climbing from the minimum established at the outbreak of the war, reached a peak in the summer months of 1917. Totals for 1918 will exceed those of 1917 only beacuse operations were paralyzed during the second half of the previous year on account of an epidemic of labor troubles. As to labor, many scattered incipient outbreaks fortunately were speedily adjusted, and so the year 1918 has been one of apparent quietude and unprecedented wage scales. The steadily decreasing volume and efficiency of labor have made it increasingly difficult to supply the war orders even at the good prices current. Naturally there were instituted but few notable additions to smelting plant—it was difficult enough to keep the old capacity satisfied. This combination of circumstances has forced many mines to retrench on exploratory work and skim the cream of their deposits, leading to a "worked-out" condition which may prove disastrous in a falling market, and certainly will require the most expert technical knowledge to bridge. It is yet too soon to appraise the effect which the return to peace will have upon the price and requirements of the metal and of the commodities and labor needed for its production. The utter absence of demand for copper may reflect a widespread opinion among the consumers that the prices of copper, as well as of other things, are war-inflated and due for a drop.

More than ever it was incumbent upon the mill superintendent to recover all the copper possible from the ore sent to him. The use of flotation, either as a substitute or adjunct to gravity concentration, had already been successfully established and had greatly improved the recovery on properly sized sulphides. How to concentrate the unfloatable copper oxides, carbonates and silicates in the tailings has received much study during the year, and several large mills have attacked their individual problems successfully. Hydrogen sulphide, alkaline sulphides and sulphur dioxide are favorite reagents added to sulphidize a sufficient area of the oxide particle so that it may float. Less soluble silicates, partially oxidized ores and tailing piles may perhaps better be first leached with sulphuric acid, when the cleaned sulphides remaining float very cleanly. Enormous and increasing quantities of copper are being recovered by such schemes at the Hurley, Hayden, Miami, Garfield and Anaconda, and have been responsible for corresponding increases in output of by-product sulphuric acid.

Adequate roasting is the kingpin of successful smelting. This has been demonstrated again at Humboldt, where the installation of a modern and ample roaster department increased reverberatory furnace tonnage so largely as to shut down the blast furnaces; the grade of matte was also increased and properly controlled, with a corresponding reduction in converter work and costs. Experiments have shown that sulphur burns out of fine concentrates as they drop from hearth to hearth at a much higher rate than while being rabbled. Since we are now able to cope with the dust problem, roaster evolution may well be toward high shafts with many narrow hearths, so that the ore will spend a larger part of its time surrounded by heated air. It has also been recognized that the fuel ratio in reverberatory smelting depends directly upon the temperature of the calcine charged. Therefore, efforts have been made to reduce avoidable radiation losses by insulating the hoppers and making a quick transfer.

Metallurgists at Douglas have made much admirable progress in their reverberatory practice. STOUT, at the Copper Queen, doubled the size of the uptakes in order to avoid choking the draft at the skimming end of the furnace, and found that he was able to burn a largely increased quantity of fuel, with even greater efficiency. COLE and JACKS at the Calumet and Arizona, following in his footsteps, found that the excessive heat at the uptake melted down the furnace arch very quickly. In trying to avoid the large losses in time and money caused by such failures, they controlled and shortened the fire zone by proper air-inlets around the burners and through the arch. Almost any step which will increase the concentration of heat appears to be desirable:—a flat verb with large flue areas, larger oil nozzles blowing superheated oil with compressed air, roof ports, double banks of burners, hotter calcine. For best results, then, an explosive flame burning fuel at the maximum rate should fill the fire-end of the furnace only as far as the last charge-hole. STOUT even advocates drawing off the gases at the middle of the furnace, converting the skimming bay into a large settler, independently heated and charged with sufficient pyritic material to wash the slags very thoroughly and thereby reduce their copper content.

By properly adjusting the length of flame and increasing its combustion rate, these Arizona plants have achieved remarkable furnace capacities and fuel ratios. Thus, the best daily average for the 19 by 100-ft. reverberatories at the Calumet and Arizona was 400 tons of calcine at a fuel ratio of 0.75 barrel oil per ton. Since revising the burning-practice these figures have increased to 800 tons at 0.62 barrel. The huge 38 by 130-ft. furnace at El Paso has done even better with 850 tons at 0.61 barrel, and has attained a remarkable daily maximum of 964 tons. The best fuel-ratio will occur when charging calcine at the maximum heat—

Capt. STOUT has set his ambition at 0.45 barrel of oil per ton of calcine charged at 1150 deg. F.

Excellent furnace practice is not confined to these oil-burning reverberatories. Thus at Garfield, by careful adjustment of combustion and charging practice, it has been possible to smelt regularly 600 tons of calcine daily with but 15 per cent of powdered fuel, while a larger furnace at Anaconda cleans 500 tons of converter slag by melting an equal quantity of partially roasted concentrates with a fuel expenditure of 8 per cent.

The question "Oil versus Powdered Coal" is of course largely decided by relative costs; it is significant, however, that plants so far from coal fields as Hayden, Clarkedale and Tacoma have recently installed powdered-coal systems.

Basic-lined converters of extraordinary size have proved their superiority wherever a sufficient quantity of matte is available to keep them in blast. Operating on 16 per cent matte, as at Anyox, they exemplify the principles of pure pyritic smelting. The use of the silica gun has more than fulfilled expectations, uniform operations and temperatures have lengthened the interval between lining repairs and allow the production of a slag higher in silica. In case converter slag is hot-charged into reverberatory furnaces, it is then more nearly of the same specific gravity and will diffuse somewhat more readily into the reverberatory slag. This may be of considerable advantage in the economical recovery of its copper content.

Adequate flue and chimney capacity is evidently essential for the best developments in reverberatory smelting. The number of Cottrell plants and high stacks recently under construction (notably El Paso, Hayden, Humboldt, Anaconda and Tacoma) indicates that many metallurgists agree with O'GARA'S ideas on smoke dissipation. One is justified in spending money only for the recovery of the actual values in the gas; the remaining more or less dangerous constituents can best be eliminated by means of stacks discharging smoke at proper temperature and proper elevation so that it will be reduced to an innocuous dilution before reaching the ground.

Iron and Steel in Last Year of War

THE salient feature of war time control of the iron and steel industry was this, that before all the direct war needs and the requirements of the "essential" commercial industries were provided for there was no steel left. Another feature was that when complete lists of all the industrial activities that were adjudged helpful toward winning the war were drawn up there were very few industries that consume steel that were left out. Two things were proved, first, that in waging modern warfare nearly all industries are needful, and second, that steel is the backbone of nearly all industries. No defined industry of any importance was omitted in the distribution of steel, but certain "purposes" were recognized, leaving other purposes unrecognized. The manufacture of passenger automobiles for public sale was not recognized, but the automobile shops were given orders for passenger vehicles and trucks for war use. Building for civilian purposes was not recognized, but there was much building for war purposes.

The condition that resulted from active participation in the war was one that was not dreamed of even by the most far-seeing when the country declared war. Then the trade engaged in speculation as to what part of the steel output would be required for war purposes, and estimates that placed the proportion at one-third were among the highest. The steel trade, usually gifted with keen vision, thought of steel demand in war time as made up of shell steel, gun steel and similar items. From such a viewpoint, all our steel could not possibly be needed, for in terms of ingots our capacity was nearly 45,000,000 tons, while the Central Powers commanded only a trifle more than 22,000,000 tons, and the Entente Allies, with the aid of steel imported from the United States, had hardly commanded as much more. Thus, apparently, only a small part of our steel would be required to upset the balance. The error lay in failing to recognize that everything possible was to be marshaled. Public service corporations would be expected to render the fullest possible service, and thus would need steel, and so with railroads, machine shops, agricultural implement factories and very nearly all the mines of every description. Instead of plowshares being beaten into swords, more plowshares were wanted.

What did the steel industry do? The division may not appeal to the purist, but the industry's output of steel may be considered from three viewpoints, of quantity, of character and of quality. As to quantity, the industry produced about 42,000,000 gross tons of ingots in 1918, when its capacity, given favorable conditions in all respects, was fully 47,000,000 tons. As to character, the industry showed a flexibility that had never been recognized in it, for it converted an altogether unexpectedly large percentage of its steel into plates, it turned out enormous quantities of shell steel through rolls that had never been thought of in connection with such sections and it made tin plate at a wonderful rate. As to quality, many mills produced steel shell and other steel of fine quality when previously they had never thought of making anything but the commonest kind of steel. The industry produced wire to tensile strength specifications that at first made the more sanguine stand aghast. It produced seamless and welded tubes of better quality than ever before. It produced and rolled electric steel for helmets that were admitted to be the best on the battlefront.

There is no doubt that the steel industry's capacity in 1918 was fully 47,000,000 tons of ingots, that estimate being based upon actual production in 1916, plus allowances, on a conservative basis, for new construction. About 2,000,000 tons output was lost in January and February through the railroad breakdown, affecting the steel industry chiefly through short supplies of coke. The influenza epidemic curtailed output in October and November, perhaps by half a million tons. There was some relaxation after the armistice, production being slightly less than would have been the case if the war had continued. Throughout the year there was a shortage of labor, and there were various minor difficulties as to the securing of supplies and equipment, that exercised some influence in limiting production. An important factor was the shortage of scrap of good quality, such as conduces to heavy open-hearth furnace tonnages.

The American steel industry, however, emerges from the war with its capacity increased about 40 per cent.

Western Chemical and Metallurgical Field

Ohio Copper Mill

THE Ohio Copper Mill at Lark, Utah, was completed late in 1909, at a cost of about $1,300,000. Erected by Heinze interests, it was one of the three big mills in the Salt Lake region treating disseminated copper ores from Bingham canyon. Unlike the ore from the Utah Copper and Boston Consolidated ground, it handled a hard, very tough quartzite slimming less in crushing than the softer porphyries. Since some rather high-grade ore from the upper levels was to be treated, Hartz jigs were installed to concentrate the coarse material delivered by Blake crushers and intermediate rolls. Jig tailings, together with coarse spigot discharges, were reground in Chilean mills. The bulk of the plant consisted of hundreds of tables; high-silica concentrates made on primary tables were recleaned on secondary tables designed to increase the copper content, while the dewatered slimes were concentrated on more Wilfleys, whose overflow was passed over slime tables before being finally discarded.

This plant was very carefully designed after large-scale tests on the ore, and incorporated the best ideas of the time. Operating on a low-grade ore, the concentration ratio reached a value of 20 to 1. Some 8 million tons of ore were treated before the steadily decreasing ore content caused the abandonment of gravity concentration.

At the present time practically all the original equipment is being removed to make way for a more compact flotation plant. Three 600-ton units are now in operation in the south end of the building, and work is well under way on two additional sections; the total capacity is thus increased while needing less than ⅔ the total building space. Fortunately, the disastrous fire occurring last August burned only the north end of the ore bins—which is the only portion of the plant containing much wood in the superstructure—and interfered but little with operations of the modernized sections. The destroyed bins are being rapidly replaced with reinforced concrete construction.

As compared to the older flow sheet, the flotation plant is simple and direct. The coarse crushing plant, capable of crushing 3000 tons per day, consists of one primary Blake and three sets of 60 by 24-in. Garfield rolls in closed circuit with 4 duplex whip-tap screens, screening to ¾ in. Until such time as the above arrangement is completed, the ore is being broken to 1½ in. in two Blake crushers before being sent to the fine-ore bins. The ¾-in. product will be washed in a locally-made drag to remove the natural slime in the ore. Primary grinding for each unit is done in the first of two 8-ft. by 36-in. Hardinge mills, which discharges into a Dorr duplex drag classifier. Oversize from the classifier enters the second Hardinge, operating in closed circuit. The overflow from the Dorr classifier goes direct to a 16-cell M. S. flotation machine.

Flotation tailings are at present passed over Wilfley tables to recover coarse sulphides, but due to the high recovery of the flotation machines they will probably be discontinued. A pair of Janney machines are being installed in each unit to clean up the M. S. concentrate. Flotation concentrates from three sections are dewatered in three 42 x 10-ft. Dorr thickeners, whose pulp feeds a pair of 12 x 12-ft. Portland filters. Lowden driers bring the moisture in the filter cake down to 15 per cent.

Original difficulties in maintaining expected extraction have been overcome by A. H. HELLER, mill superintendent, by removing the natural slime occurring in the ore, which exerts an influence on recovery out of all proportion to its absolute quantity. As previously noted, this is effected by washing the fine ore in a locally made drag, capable of handling material up to ¾ in. without difficulty. Careful attention to the relative proportions of coal tar and pine oils is necessary so that no unoiled particles of sulphides appear when panning the tailings. The profitable treatment of such low-grade ore, mined by expensive underground methods during times of high commodity and labor costs, is an achievement of more than ordinary merit.

The Joplin Zinc Situation

AT THE instance of POPE YEATMAN of the War Industries Board, a committee from the Joplin Ore Producers' Association met with a committee representing the zinc mining and smelting industry in its relations with the government during the middle of October, and formulated an agreement effective for three months which was designed to reduce the wide "spread" between the price of metal and ore which has recently caused a sharp curtailment of mining. According to W. B. SHACKELFORD, a member of the conference, the agreement was based on the following figures:

Cost of producing 60 per cent. concentrates, including royalty: $60 per ton.

Cost at gas smelters, not including risk of failure of fuel supply: $23.50 to $26 per ton.

Cost at coal smelters, not deducting return for acid: $32.50 to $34 per ton.

Average cost of smelting, basis: zinc at St. Louis: $30 per ton.

Smelter recovery: 83 per cent.

Thus it was found that if the spelter market were quoted as $8.75 per hundred pounds and the ratio between metal and ore were at 6.52, the mine and smelter would both receive about enough to pay their expenses. Therefore it seemed proper to adjust a sliding scale such that when the spelter market was quoted at $6 per hundred the price of 60 per cent ore would be 6.80 times the price of zinc, or $40.80. The ratio decreases by one hundredth for each tenth of a cent advance in zinc per pound; thus, at a 10-cent market, the ratio is $6.80 - 0.01(10.0 - 6.0) = 6.40$, and the price of ore would be 10×6.40 or $64, subject to the usual premiums and penalties for composition. To stabilize the market the agreement further specified that the smelters would obligate themselves to absorb a certain amount of ore weekly for the period of the agreement.

In order for the plan to become effective it was necessary for practically all the smelters handling Joplin ore to sign the agreement. About 70 per cent of the smelter tonnage signed, and nearly all the mines in the district became a party to the agreement. During the

first week, the signatory smelters purchased 2400 tons at the agreed price of $55.67, while outsiders secured 1300 tons at from $52.50 to $55. During the week ended Nov. 17, however, many buyers remained out of the market, and but 2300 tons were purchased at the agreed price of $54.53, while 1700 tons were picked up at prices ranging down to $45. Unfortunately the agreement contained no stipulation binding the miners to refuse offers at less than the agreed price, and many in financial straits were forced to realize on their concentrates.

Joplin ore producers therefore voted on Nov. 16 to curtail or suspend operations in view of the very large accumulation of unsold concentrates, leaving the situation in the hands of "outlaw" miners and buyers.

Suspension was contingent, however, upon obtaining signatures of 60 per cent of the production, which was not forthcoming. Smelters then agreed to state the weekly amount of ore required, which would then be allocated among the mines. Completion of storage warehouses for 150,000 tons of ore is also expected to stabilize the situation materially, since miners could borrow 90 per cent of value on warehouse receipts. Meantime spelter is dull and weak and the situation is disarranged by sales of a large amount of concentrates at the market by a big company on telegraphic orders from the owner.

Curtailment and shutdowns are now the order of the day for higher cost producers; in fact, the sheet ground region near Duenweg is practically abandoned at present.

Ferromanganese at Great Falls, Mont.

OPERATION of the ferromanganese department at the Great Falls plant of the Anaconda Copper Mining Co. began about the middle of September, when the first of the electric furnaces was started. The proposed plant was briefly described on page 391 of our issue of April 15, 1918, construction having started early in March.

Each of the furnaces consists of an open-topped shallow brick shaft, 28 x 14 x 11 ft. in outside dimensions. The outer walls are of red building brick with an inner firebrick lining. This shaft has a tamped lining composed of dead burned magnesite with pitch as a binder. The tamped lining is 3 ft. thick in the bottom and is brought up the sides to a point about 18 in. above the tap-hole level. The inner dimensions of the shaft at the middle section are 22 x 9 ft. The furnace is 6 ft. deep. The furnace is operated on 60-cycle, three-phase alternating current. Two 24-in. round electrodes are used in a common holder on each phase. The electrodes are spaced 6 in. apart in the holders and the pairs about 5 ft. on centers.

Electric power is delivered at 100,000 volts from nearby hydro-electric plants of the Montana Power Co. and is transformed to furnace voltage, 115 volts, in two steps, 6600 volts being the intermediate point. Each furnace is equipped with one General Electric polyphase transformer rated at 5630 kva. Each furnace has a rated power consumption of 3500 kw. and an output of 18 tons of 80 per cent alloy daily.

A very considerable quantity of carbonate ore of the following approximate analysis has already been blocked out in the upper levels of several of the Butte mines belonging to the Anaconda Copper Mining Co.

Moisture	1.82 per cent
Manganese	35.89 "
Silica	9.34 "
Iron	2.0 "
Alumina	2.15 "
Magnesia	2.50 "

Six parts of this ore will be reduced by two parts of a local bituminous coal; the mixture will also contain about one part limerock to flux the impurities in the ore and coalash. Sufficient iron ore will also be charged to bring up the iron content in the resulting metal. The proper mixture is delivered to charge hoppers by overhead crane, the furnaces themselves being built in the north end of the main smelter building opposite the abandoned copper blast furnaces.

Metal and slag are tapped together into pots. The waste slag is skimmed and the metal cast by a casting machine formerly in use for casting copper.

E. S. BARDWELL, superintendent of the ferro-alloy department of the Anaconda company, hopes to have the five furnaces running to capacity within six weeks, when he will have the world's largest ferromanganese plant in operation. About seventeen pounds of 80 per cent ferro is required to deoxidize a ton of open-hearth steel; thus the daily production of ninety tons at Great Falls will annually satisfy the requirements of 3¾ million tons of mild steel. An idea of the importance of this one plant may be had from the statement that its production will care for 8 per cent of the entire yearly production of steel ingots in the United States and will release six or seven 5000-ton ships from transporting Brazilian manganese ore to this country.

Iron and Steel Metallurgical Society

THE need for a metallurgical society exclusively confined to the metallurgy of iron, steel and their alloys has been keenly felt for a long time. Metallurgists prominently connected with this branch have from time to time expressed themselves to this effect. Recently several of them discussed the matter in a definite way at a meeting held in the Fort Pitt Hotel, Pittsburgh, when the formation of a society was decided upon. Its aim and object is the promotion of the arts and sciences connected with the metallurgy of iron, steel and their alloys.

A committee to consummate the plans of this meeting was appointed, of which Mr. D. L. MATHIAS of Mackintosh, Hemphill & Co. was selected as chairman, who are taking steps to materialize the society. Before the society can be a real force, the active co-operation of those eligible for membership will, of course, be needed.

The committee will be pleased to answer inquiries and furnish information to those interested.

Operation at Grand Forks—A Correction

In our issue for Oct. 15, 1918 (Vol. 19, p. 606), the statement was made in error that the Grand Forks smelter had been shut down. Mr. W. A. WILLIAMS, supt. of smelters for the Granby Consolidated, informs us that the plant continues to operate three furnaces, since smelting at this point has been successfully maintained irrespective of the grade of ore so far available.

Muscle Shoals Nitrate Plant

Description of the Largest Synthetic Nitrogen Works in the World—Cyanamide Process—Lime and Coke, Carbide Furnace and Milling, Liquid Air, Oxygen and Nitrogen, Ammonia, Catalytic Oxidation and Nitric Acid Departments Detailed

By ANDREW M. FAIRLIE
Consulting Chemical Engineer, Atlanta, Ga.

MILITARY explosives may be divided, according to the uses to which they are put, into two classes: Propellants for hurling projectiles, and high explosives for bursting the bombs or shells. Both classes are nitrogen compounds made from nitric acid or ammonia or both. The propellants are made by treating cotton or glycerin with nitric acid, and the bursting explosives are made by treating toluol, benzol or ammonia with nitric acid. The names of the three most important bombing or shell-bursting explosives are trinitrotoluol (TNT), trinitrobenzol (picric acid) and ammonium nitrate. Since the cost of either TNT or picric acid is about two and one-half times the cost of ammonium nitrate, it became plainly important, soon after the United States entered the great war, to increase the supply of nitrate of ammonia in this country as rapidly as possible.

At the same time it became distressingly evident to the chemists of the country that this nation was entirely dependent upon a foreign country for its supplies of the only chemical from which nitric acid could be made in quantity. This chemical—nitrate of soda—had to be imported over thousands of miles of ocean from Chile, and it was forcefully realized that if this country should become involved in war with any nation which could gain control of the seas and thus cut off our supplies of nitrate of soda, we would be unable to make ammunition, and hence we would be at the mercy of a foreign power. Added to this was the knowledge that a large fleet of ships was required to transport from Chile the large tonnage of nitrate of soda so urgently needed for munition-manufacture, ships which were sorely needed for the transport of troops and supplies to France and could not well be spared for the long journey to South America. Furthermore, the manufacture of nitric acid from nitrate of soda requires the consumption of large quantities of sulphuric acid, of which there was already a serious shortage.

Steps to Overcome Vulnerable Position

In this emergency and with the realization that the output of a plant for the manufacture of nitrates could be used in time of peace for fertilizers as well as in time of war for munitions, the Ordnance Department determined to correct the vulnerable position of the country and to render the United States independent of foreign countries for the manufacture of nitric acid and nitrates.

Since in this country no extensive beds of natural nitrates exist, artificial nitrates had to be made, and the only existing sources were (1) the gases of the by-product coke ovens, and (2) the nitrogen of the atmosphere.

The capacity of by-product coke ovens had already been doubled since August, 1914. The cost of construction of these ovens had risen to about two and one-half times the normal cost. To furnish the amount of ammonia needed from this source could have required another doubling of capacity, at an expenditure of money and consumption of valuable time which would have been intolerable. The only practical source of artificial nitrates appeared to be the unlimited quantities of nitrogen in the atmosphere.

In the fall of 1916, Dr. Charles L. Parsons, Chief Chemist of the Bureau of Mines, who had been sent abroad to investigate European methods for the fixation of atmospheric nitrogen, returned to this country and submitted his report.

Important Processes for Fixation of Atmospheric Nitrogen

The three most important processes in commercial use were known to be the arc process, the Haber process, and the cyanamide process. In the arc process air is blown through a flaming electric arc which burns the nitrogen to nitric oxide, and this is absorbed in water or milk of lime to make nitric acid or nitrate of lime. Its successful use has been limited to localitites such as exist in Norway, where enormous hydro-electric power can be generated at very low cost. There is no water-power site in this country which can compete as to cost of power generated with the Norwegian sites. The Haber process combines nitrogen and hydrogen, mixed in the right proportions for chemical combination, at a very high temperature and pressure, by means of a catalyzing agent, thus forming gaseous ammonia, which can be burned by passing through incandescent platinum gauze to form oxides of nitrogen, which in turn can be passed through towers sprayed with water to form nitric acid. The practicability of producing ammonia and nitric acid by a modification of the Haber process had already been a subject of investigation by the Nitrate Supply Committee of the War Department, and a plant using this process to be erected at Sheffield, Alabama, with a capacity equal to 22,000 tons of ammonia nitrate per annum, had been contracted for. This plant, known officially as U. S. Nitrate Plant No. 1, was being built under a Congressional appropriation of $20,000,000. It was also planned to test several other new processes at No. 1 Plant. However, none of the processes to be tested at Plant No. 1—not even the modified Haber process—had ever been operated successfully on a commercial scale[1] and could not therefore be fully depended upon; therefore, the Ordnance De-

[1]The true Haber process, said to be operating successfully in Germany, was not known in this country in all its details.

partment was unwilling to commit itself to the extension of any of these uncertain processes, and instead resorted to a consideration of the cyanamide process.

The Cyanamide Process

The dependability of the cyanamide process had already been proved by actual commercial operations over a period of years. Cyanamide had been manufactured continuously since 1909 at Niagara Falls, Canada, and since the outbreak of the war the plant there had had a capacity of 64,000 tons per annum. A considerable part of the cyanamide produced had been converted into ammonia since the early part of 1915 and had been used in producing ammonium nitrate for the Allies. A plant for the oxidation of ammonia, produced from cyanamide, to nitric acid had also been in continuous operation on full-sized equipment for more than a year. The patents for producing chemicals by the cyanamide processes were controlled by the American Cyanamid Co.

With these facts in mind the Ordance Department, in the fall of 1917, invited the American Cyanamid Co. to present some plan for the manufacture of ammonium nitrate on a large scale. The plan presented was for the manufacture of ammonium nitrate from air, steam and water, by means of the common materials limestone, coal and coke. One or more plants, it was shown, each complete in itself, could be built within twelve months to supply the entire quantity of ammonium nitrate desired. There was to be nothing experimental or untried about the project. All that would be required would be to reproduce, on any scale desired, the several elements of existing installations successfully operating. The cost of construction would be only a small fraction of the cost of building by-product coke-ovens of equal ammonia capacity.

At the request of the War Department the American Cyanamid Co. formed a subsidiary company, known as the Air Nitrates Corporation, to act as the agent of the United States Government for the construction and operation by the cyanamide processes of a plant at Muscle Shoals, Alabama, to produce 110,000 tons per annum of ammonium nitrate. This plant is known as U. S. Nitrate Plant No. 2, to distinguish it from Nitrate Plant No. 1, referred to above.

U. S. Nitrate Plant No. 2

Nov. 16, 1917, was the date on which it was decided to construct the new plant. The first carload of material was delivered on Dec. 20 the same year, and the first ground was broken on Feb. 16, 1918. Since then more than 20,000 men have been employed on construction of the plant. The site for Nitrate Plant No. 2 is on the Tennessee River at Muscle Shoals, in the northwest corner of the State of Alabama, between the towns of Sheffield and Florence. The nearest railroad station is at Sheffield, some three miles away, served by the Louisville & Nashville Railroad and the Southern Railway. The site occupies 2,200 acres, including a permanent town built to accommodate 12,000 people, composed of two communities, one for white people and the other for negroes. Temporary quarters had to be rushed first, however, for the thousands to be employed in construction work, and by May a mushroom city of 20,000, with lodgings, restaurants, offices, police headquarters, hospitals, motion-picture theatres, telegraph, telephone, electric light and sewerage systems and many other necessities and conveniences of modern urban life, covered the ground which had been growing corn and cotton or over which the native Alabaman had hunted the rabbit and raccoon the preceding fall.

Ten Operating Departments

The complete plant includes ten operating departments, each housed in one or more separate buildings, an office, shops, laboratories and other general service buildings. The important operating departments are as follows:

1. The power plant.
2. The carbide-materials department.
3. The carbide-furnace department.
4. The carbide-mill department.
5. The nitrogen department.
6. The lime-nitrogen department.
7. The lime-nitrogen-mill department.
8. The ammonia-gas department.
9. The nitric-acid department.
10. The nitrate department.

The entire plant is so laid out that beginning at the carbide-materials department, located some 3600 feet south of the Tennessee River, the main product of each department will proceed to the next department continuously from north to south, in the order named above. An exception to this rule is the nitrogen department, which, producing a material to be used first in the lime-nitrogen department, has been placed far to the east of the lime-nitrogen building, for reasons to be explained later.

The Power Plant

Ultimately, power for Nitrate Plant No. 2 will be furnished by the large hydro-electric plant to be constructed by the Government on the Tennessee River at Muscle Shoals. This proposed hydro-electric plant will form the subject for a long story in itself. It will suffice here to say that the development of this power will necessarily consume so much time that Nitrate Plant No. 2 could not wait for it, and it was decided to build a steam plant for use in the interim. The hydro-electric plant being therefore not essential for the operation of the nitrate plant, work on it was discontinued some months ago; but since the signing of the armistice with Germany it has been announced that this work has already been resumed.

The electric requirements of the various departments of the Nitrate Plant are estimated at 90,000 kw., 60,000 of which will be furnished by the large steam plant now under construction, and 30,000 will be generated by the Alabama Power Co. in a Government-owned extension to the Warrior steam power plant of that company situated in the Alabama coal fields at Gorgas on the Warrior River and transmitted 88 miles to the plant.

Steam-Power Plant Designed to Develop 90,000 Kilowatts

The steam power plant of Nitrate Plant No. 2 is located on the south bank of the Tennessee River about 3600 ft. north of the nearest plant building. It has been designed to develop, if necessary, the entire 90,000 kw. needed, by means of two units, Unit 1 of 60,000

kw. capacity, and Unit 2 of 30,000 kw., but in view of the resumption of work on the Tennessee River power development, it is not likely that the equipment for Unit 2 will ever be installed.

The boiler room (158 ft. 9 in. x 228 ft. 6 in.) will contain the 12 boilers of Unit 1, B. & W. Stirling type, water tube, each developing 1500 hp., and each equipped with B. & W. superheater and Diamond soot blower. The steam end of Unit 1 will be subdivided into three units of 20,000 kw. each. The turbine room is 170 ft. x 88 ft., equipped with Westinghouse turbines and generators—the latter A.C., 60 cycle, 3-phase, 12,200 volts. The turbines will be operated by steam at 275 lbs., 175 deg. F. superheat, and 28.5 in. of vacuum. The electrical accessory room (191 ft. x 35 ft.) will contain the necessary motors, batteries, rheostats, etc. The power house equipment includes also the necessary blowers for forced draft on the boilers, pumps, condensers, etc. Water for the condensers is taken from a coffer dam in the Tennessee River just north of the plant. Coal is brought into the plant in hopper-bottom cars on an overhead track, and is dumped into crushers, and the crushed coal is carried by screw-conveyors to the bunkers.

On Nov. 15 much work still remained to be done on the installation of the equipment of the power house, but it was then expected that the first 20,000 kw. subdivision of Unit 1 would be operating by Jan. 1.

Bus-Tunnel

The electric current at 12,000 v. will be transmitted from power-house to plant through a special bus-tunnel. This tunnel (built on the surface for the greater part of its length and underground for only about 200 ft.—at the point where railroad tracks will cross it) is 22 ft. 10 in. wide x 8 ft. high x 3600 ft. long. It is built of brick and concrete and has a gable roof of concrete

FIG. 1. ONE OF THE LIMEKILNS

slabs, covered with 3-ply felt and tar. Pent-houses at intervals of about 500 feet afford ventilation and means of access to the compartments of the tunnel. There are three compartments extending the entire length of the tunnel, separated by concrete walls. The two outside compartments are 5 ft. 8 in. wide inside and the middle compartment 8 ft. 10 in. wide. Attached to the concrete dividing walls are insulators which support the copper bus-bars. Each of the two dividing walls carries two bus-bar circuits—one circuit on each side of the wall. Thus there is one circuit in each of the two outside compartments of the tunnel, and two circuits in the middle compartment. Each circuit consists of 3 buses, supported one above the other on the wall and about one foot apart, and each bus is composed of two horizontally parallel copper bars, each ¼ in. thick x 4 in. wide. Expanded metal screens two feet away from the bus-bars will prevent persons who may be in the tunnel from coming in contact with the high voltage circuits, and will provide a safe passage for attendants or workman, 4 ft. 10 in. wide in the middle compartment, and 3 ft. 8 in. wide in the two outside compartments. Safety signals will also be provided to indicate whether the bars are alive or not. Provision has been made also for fire-doors by means of which one section of a compartment may be shut off from another.

At its upper end the tunnel terminates at the switch-house, where the electric current is diverted to the various departments requiring power.

The Carbide-Material Department

The purpose of the carbide-material department is to produce the quicklime and the crushed coke required by the carbide-furnace department, and its main functions are:

1. To pulverize the coal for the limekilns and coke driers.
2. To calcine (or burn) limestone in the limekilns, to form quicklime.
3. To crush and dry coke.

The limestone, quarried and crushed to sizes of from ½ in to 2 in. at the Government quarries at the Rockwood District near Russellville, Alabama (28 miles distant), is discharged from cars on a track at the north end of the limekiln building. The unloading of the cars is done either by dumping from drop-bottom cars or with the locomotive crane, as may be required. The crushed and sized limestone is carried by a conveyor belt to a bucket elevator, by means of which it is hoisted to an upper floor and distributed by means of a conveyor belt among seven concrete silos or bins, each of 6000 cu.ft. capacity.

A typical analysis of this limestone is:

Silica (SiO_2)	0.49 per cent
Alumina (Al_2O_3) and iron oxide (Fe_2O_3)	0.30 per cent
Calcium carbonate ($CaCO_3$)	98.23 per cent
Magnesium carbonate ($MgCO_3$)	0.97 per cent
Moisture and loss on heating to 175 deg. C.	0.07 per cent
Total	100.06

From the silos the limestone goes to a cradle feeding device, made by the Fuller Car-Wheel Manufacturing Co. of Catasaqua, Pa., which regulates the flow of limestone into the limekiln.

The limekilns are seven in number, each 8 ft. in diameter and 125 ft. long. Four of them were made by Reeves Bros., Alliance, Ohio, and the three others by the Allis-Chalmers Co. Fig. 1 is a photograph of one of these kilns. The kilns are nearly horizontal, having a pitch of 5 ft. in 125 ft. of length. They are steel shells lined with fire brick, and are rotated at the rate of about ½ r.p.m. by means of a beveled gear. The limestone is fed in at the upper end, and at the lower end the kilns are fired with powdered coal by an air blast. The temperature in the kiln is from 1400 to 2000 deg F. The product is quicklime and the reaction which takes place in the kiln may be expressed thus:

$$CaCO_3 = CaO + CO_2.$$

The process is continuous, but from three to four hours are required to complete the burning of the limestone. The capacity of the kilns is about 200 tons of

raw limestone per day each, equivalent to about 100 tons of burned lime. When the plant is fully tuned up, the combined capacity of the seven kilns will be from 1400 to 1600 tons of limestone per day.

From the limekilns (or limestone-burning kilns) the quicklime is discharged into seven horizontal cooling kilns, each 5 ft. in diameter and 50 ft. long, which revolve at the rate of about 3 r.p.m. The cooled quicklime is then conveyed to the raw materials building.

The coal-mill building (50 ft. x 125 ft.) situated alongside the kiln building, contains a coal bin, from which the coal is delivered to a crusher, thence to a steel silo, then to a coal drier. The latter is a rotary steel shell 42 ft. long x 3.5 ft. in diameter, fired externally by hand. The dried coal is carried up by elevator to steel silos from which it is fed to four Fuller 42-in. pulverizer mills. Thence it is carried up an elevator to a screw conveyor which takes it to small steel silos of which there is one opposite each limekiln. From these it is fed as needed, by means of an air blast, into the limekilns to effect the burning of the limestone.

At the coke-drier building, just east of the limekiln building, coke is dropped into hoppers underneath the track, and conveyed by belt conveyor to two crushers, where, after screening, the coarse is crushed to nut size and the crushed coke is then conveyed to two concrete silos, capacity 15,400 cu.ft. each, and thence fed down into four rotary driers, fired with coal. After drying, the coke is carried by belt conveyor to eight silos (capacity 6600 cu.ft.) in the raw-materials building, for use in the carbide-furnace department.

The raw-materials building (52 ft. 8 in. x 102 ft. 8 in.), located next to the limekiln building and south of it, is for the storage of the crushed coke and the quicklime, and designed to keep these materials as free from dampness as possible. From the bins in this building the materials are weighed in the desired proportions and mixed. The weighing apparatus beneath the two bins at the south end of the building consists of two 36-in. Schaffer poidometers, manufactured by the Schaffer Engineering and Equipment Co., of Tiffin, Ohio. These operate continuously, one for limestone and one for coke. They can be set to weigh the exact proportion desired, and both limestone and coke are delivered to the same conveying belt and carried to the carbide room.

Beneath the other bins there are three 8000-lb. scale hoppers, arranged for weighing either limestone or coke. The materials go from the scales to a conveying belt, to a bucket elevator, to another conveying belt, then in the carbide-furnace building are distributed among 24 steel silos, whence the charge, already mixed, can be dumped through chutes on to the charging floor of the carbide furnaces.

Carbide-Furnace Department

In the carbide-furnace building quicklime and dried crushed coke are heated to high temperature in an electric furnace, to form calcium carbide (CaC_2).

The size of the carbide-furnace building is 90 ft. x 1050 ft. and nine-tenths of this space is occupied by the carbide furnaces and their equipment. The building is the next building south of the raw-materials building, and its length extends from east to west, and its width from north to south. The carbide furnaces, of which there are twelve, are rectangular in shape, 12 ft. x 22 ft. x 6 ft. deep inside. They are merely steel boxes, open at the top and lined with firebrick.

At the east end of the carbide-furnace building there is a room 90 ft. x 100 ft. set apart for the assembly of the electrodes for the furnaces. The electrodes reach this room in the form of carbon blocks 16 in. square x 6 ft. 5 in. long. The assembly of electrodes consists in the following process: An area is planed at each side of one end of these carbon blocks, so that a metal head may make a good electrical contact. At the same end of each carbon block two holes are bored, and a copper electrode head is secured to it by special bolts. Then three of these blocks are fastened together as a unit and covered by wire netting and a protecting layer of heat-resisting cement (a mixture of asbestos and retort cement) which is baked on in an electric furnace. One complete electrode, assembled as described, weighs 7000 lb. Pipe connections are made to the electrode heads, which are provided with a water-cooled system, for cooling the electrodes while in service.

Three of the complete assembled electrodes are suspended from suspending arms over the top of the furnace. The depth of immersion of the electrodes in the molten bath is controlled automatically on the electric switchboard. The bus-bars carrying current to the electrodes are $\frac{5}{16}$ in. thick x 8 in. wide, and there are 16 bars to each electrode. The voltage for the carbide furnaces is 130 v. stepped down from 12,000 v. by G. E. transformers. There is one bank of transformers for each furnace, the capacity of each bank being 8325 kw. The current used at present is 15,000 amp., but when operating normally the current will be 20,000 amp. The normal capacity per furnace is 50 tons per day of 24 hours. The temperature attained in the furnace is 3000 deg. C. During the reaction the electrode is consumed at the rate of 70 lb. of carbon per ton of carbide manufactured. The reaction may be expressed thus:

$$CaO + 3C = CaC_2 + CO$$

The carbon monoxide burns at the top of the furnace and escapes as carbon dioxide.

On the bottom of the furnace is placed one layer of graphite electrodes, 16 in. square x 48 in. long. On top of this layer of electrodes is placed a layer of tar and gravel. In starting a furnace, a layer of crushed coke is thrown in on the bottom. The charge is put in on top of the layer of coke and the current is turned on. The charge consists of a mixture of quicklime and dried crushed coke, in the proportions of 1000 lb. of the former to 600 to 620 lb. of the latter. This mixture is made up in the raw materials building and conveyed to the charging floor of the carbide furnaces as previously described, and is shoveled into the furnace until it is full to the top. The first tap is made six hours after starting, and thereafter the furnace is tapped every 45 minutes, the furnace being kept full to the top all the time by men on the charge floor, shoveling in the mixture as required.

The furnace is tapped by burning out the tapping hole with a portable electrode, whereupon the molten carbide flows out into "chill cars" of one-half ton capacity each. After tapping, the tapping hole is stopped by throwing a few shovelfuls of powdered carbide at

the outlet. The outflowing mass soon solidifies and the flow is stopped. The chill cars containing the hot carbide are hauled by electric locomotives operated by storage batteries to the carbide-cooling building, which is a part of the next department.

Carbide-Mill Department

The carbide mill department is responsible for cooling, crushing and pulverizing of the carbide for use in the lime-nitrogen department. The carbide-cooling building (950 ft. long x 50 ft. wide) is located south of the carbide-furnace building and parallel to it, and is connected to it by six passageways each 50 ft. x 50 ft. As contact with water will produce acetylene, care must be taken in cooling to protect the carbide from rain and snow. The buckets containing the carbide pigs are picked off the cars by a traveling crane, and set aside to cool. During the process of cooling, considerable shrinkage takes place; when sufficiently cooled, the pigs or blocks of carbide are dumped out of the buckets on to the crusher platform.

The following is a typical analysis of the manufactured carbide:

CaC_2	82.30 per cent	Ca_3P_2	0.07 per cent
C	1.20 per cent	CaS	0.13 per cent
CaO	14.72 per cent	FeSi	0.72 per cent
CaSi	0.06 per cent	Undetermined.	0.80 per cent

The carbide-crusher building (120 ft. x 150 ft.) contains three 36-in. x 42-in. Buchanan crushers, which crush the carbide to about 1¼-in. size. After crushing, the material goes by elevator to a bin which supplies the Hardinge mills, of which there are three. These grind the carbide so fine that 80 per cent of it will pass through a 40-mesh screen, and the balance through a 10-mesh screen. From the Hardinge mills the powdered carbide goes to three Smidth tube mills, which pulverize the carbide still further, so that 85 per cent will pass through a 200-mesh screen, and the product is known as milled carbide.

While going through the process of milling, the carbide must be protected from the moisture of the air, which, acting on the finely divided carbide, might react with it, forming acetylene, a gas of an explosive or inflammable nature when mixed with air. The grinding and milling of the carbide are therefore done in an atmosphere of nitrogen, this inert gas being piped to the carbide-crusher building from the liquid-air building, for use in the grinding and pulverizing mills.

The milled carbide is conveyed to eight steel bins or storage silos in the lime-nitrogen building. The pulverized carbide constitutes only one of the two important raw materials for the manufacture of lime nitrogen; the other one is the nitrogen.

Nitrogen Department

The nitrogen is obtained from air in the liquid-air building. The process, described briefly, consists in the compressing and cooling of air until it becomes liquid, then in the fractional distillation of the liquid air to separate the nitrogen from the oxygen in much the same manner as alcohol is separated from water, advantage being taken of the different temperatures at which the two gases change from the liquid state to the gaseous.

The liquid-air building (100 ft. wide x 575 ft. long) is located ¼ mile to the east of the lime-nitrogen building. The object of this isolation is to have the air intakes and the equipment of this department away from the contaminating gases of the other departments of the plant.

The air intakes for the liquid-air process consist of two 36-in. pipes, which extend, one north and the other south, for 1600 ft. in either direction, from a point opposite the center of the building, on the east side, for the sake of getting a supply of pure air. By means of Root cycloidal blowers the air is drawn through the intakes and then is forced through eight sets of scrubbing towers (two towers to a set). These towers, 8 ft. in diameter and 30 ft. high, are packed with 6-in. spiral rings. The towers are fed with a solution of caustic soda (17 deg. Bé.), a fresh solution to each tower. The object of the scrubbing of the air is to remove impurities, chiefly the 0.04 per cent of carbon dioxide, which, if not removed, would give trouble in the subsequent operations by freezing. The caustic liquor discharged from the scrubbers goes to the ammonia-gas department, where the carbonate is removed, and the caustic solution made up to strength and returned to the liquid-air department. From the second towers the air goes to the main header, and is thence supplied to the compressors.

The Liquid-Air Plant

The engineer who designed the liquid-air plant is Herman Van Fleet of Philadelphia. Fundamentally the process used is the Claude process. There are 15 twin-duplex compressor units, furnishing air at 600 lb. pressure to 30 nitrogen columns. Seven of these compressors were furnished by the Ingersoll-Rand Co. and eight by the Norwalk Iron Works. The compression is done in three stages: 30 lb., 140 lb. and 600 lb. Of the 30 nitrogen columns, 24 will be operating normally—the six others being spares. The nitrogen columns were made by the Ansonia Brass and Copper Co., Cincinnati, Ohio, and the rights to their use are controlled by the Air Reduction Co. The columns, oval in shape, are about 4½ ft. in diameter and 24 ft. high. The rectifier in the nitrogen column consists of a series of superposed horizontal trays, each about 1½ in. deep, on which rests a body of liquid through which the rising gas must bubble.

The compressed air from the Norwalk or Ingersoll-Rand compressors is allowed to expand from 600 lb. to 50 lb. In expanding, the air operates a small engine, generating thereby about 4 to 5 hp., this power going to waste. The air at 50 lb. pressure enters the rectifier, and at this stage is below the critical temperature of air (—140 deg. C.). A small part (about one-tenth) of the air at 600 lb. is admitted to the rectifier at that pressure, and the increased pressure on the cold air at 50 lb. pressure liquefies the air. The liquid air then begins to distil. Oxygen liquefies at —182 deg. C. and nitrogen at —195 deg. C. Oxygen, therefore, tends to remain liquid, and the nitrogen tends to go over into the gaseous state. Therefore, a liquid rich in oxygen (45 to 50 per cent O) is found at the bottom of the rectifier, and the gas in the rectifier gradually becomes richer in nitrogen as it approaches the top. At the top of the rectifier the gas is sprayed with liquid nitrogen, and gaseous nitrogen, 99.9 per cent pure, escapes.

Tests of the percentage of oxygen in the gas mixture inside the rectifier are made from time to time, for regulation of the apparatus.

The nitrogen is passed through two pipe heat-exchangers, to recover the cold, then goes to the nitrogen header, then through a 30-in. main to the lime-nitrogen building. The nitrogen escapes from the rectifier under a pressure of 10 in. of water and goes to the lime-nitrogen building under a pressure of 4 in. of water. Each nitrogen column produces nitrogen at the rate of 500 cu.m. (1765 cu.ft.) per hour. The oxygen is passed through the heat-exchanger and is then allowed to escape into the atmosphere of the building.

The illustration (Fig. 2) is a photograph of the interior of the liquid-air building. In the middle foreground is one of the nitrogen columns with its engine and heat-exchangers and other nitrogen columns can be seen farther to the right. At the left, in the background, is one of the duplex-compressor units.

The compressors for the service air for the entire nitrate plant have for convenience been installed in the liquid-air building, at the north end. For furnishing service air there are five Sullivan two-stage angle compound air compressors, furnishing air at 100 lb. The air goes to the compressors through a 28-in. intake, and is delivered to the plant through two 10-in. mains, which are so connected that one can be shut down for repairs if necessary without interfering with the air service to the plant. These five compressors have a combined capacity of 10,000 cu.ft. of free air per minute.

Lime-Nitrogen Department

The lime-nitrogen building is 250 ft. wide and 520 ft. long, and is located south of the carbide-mill building. In this building the milled carbide and the nitrogen are brought together to form lime nitrogen, commercially known as crude cyanamide.

There are sixteen rows of lime-nitrogen ovens and 96 ovens in a row—1536 ovens in all. Eight rows of the ovens are located on the west side of the building, occupying 100 ft. of the width, and the other eight rows on the east side likewise occupy a space 100 ft. wide, leaving a space 50 ft. wide in the center, extending from north to south, which is used for the manufacture of the paper containers and tubes employed in charging the ovens.

The ovens are 4 ft. 4 in. outside diameter x 2 ft. 10 in. inside diameter x 5 ft. 4 in. deep. They consist of a steel shell with a 9-in. lining of Evans & Howard fire-brick. To charge the oven a cylindrical paper container 2 ft. 6 in. in diameter, with a vertical paper tube 3 in. in diameter in the center, is inserted in the cold oven, and the charge of about 1600 lb. of pulverized carbide is put in. There will be an annular space about 2 in. wide between the paper container and the brick lining of the oven. The carbon electrode, a $\frac{5}{8}$-in. pencil 6 ft. 6 in. long, is inserted inside the paper tube. Two covers are put on, the outer cover being luted with sand.

For bringing the nitrogen to the ovens there is an 8-in. spiral riveted pipe between each pair of parallel rows of ovens, and from this two $1\frac{1}{2}$-in. pipes convey the nitrogen to the oven—one to the bottom, at the center, and the other at the side, 6 in. above the bottom—each provided with a valve. The nitrogen reaches the oven under a pressure equal to 3 to 4 in. of water.

When everything is ready, the electric current (single phase) is turned on at 100 volts and 200 to 250 amp. for 20 minutes, then it is reduced to 50 volts and 100 to 115 amp. for 12 hours. Then, as the reaction is exothermic, the current is shut off and the reaction allowed to continue 28 hours longer. The temperature

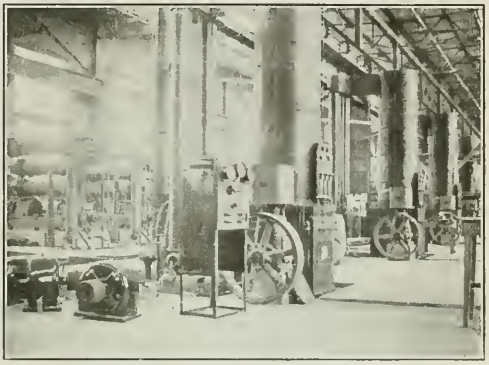


FIG. 2. NITROGEN COLUMNS, LIQUID-AIR BUILDING

attained in the oven is about 2000 deg. F. The material is not melted, but sinters together to form a solid cake.

In the oven the nitrogen is absorbed by the carbide, and carbon is set free, the chemical equation being:

$$CaC_2 + N_2 = CaCN_2 + C$$

A typical analysis of the lime nitrogen follows:

$CaCN_2$	63 per cent	SiO_2	3 per cent
CaC_2	2 per cent	MgO	2 per cent
CaO	13 per cent	Fe_2O_3 and Al_2O_3	2 per cent
CaS	1 per cent	Miscellaneous	3 per cent
C	11 per cent		

For removing the cakes or blocks of lime nitrogen, and otherwise serving the ovens, an industrial track has been provided in the building with cars drawn by gasoline locomotives. The finished cyanamide is taken to the lime-nitrogen-mill department for cooling.

Lime-Nitrogen-Mill Department

The lime-nitrogen-mill department has three functions to perform:

1. To cool the cyanamide pigs.
2. To crush and mill the cyanamide.
3. To remove from the cyanamide some of the undecomposed carbide by a hydration process.

The lime-nitrogen-cooling building (50 ft. x 350 ft.) is at the south end of the lime-nitrogen-oven building. It is served by two 20-ton Whiting cranes. The cooling of the cyanamide blocks does not require as much care as was the case with the carbide pigs, as the material does not now combine readily with water to form acetylene gas. After cooling, the cyanamide blocks are crushed and pulverized.

The cyanamide-mill building is an exact duplicate of the carbide-mill building. The cyanamide is pulverized so that 95 per cent will pass through a 200-mesh screen.

All grinding and pulverizing is done in an atmosphere of nitrogen. The milled cyanamide is taken to nine large concrete silos in the lime-nitrogen-silo building (56 ft. sq. x 76 ft. high), south of the mill building. From these silos the material goes to the hydrating building (size 50 ft. x 80 ft.). Here the milled cyanamide is conveyed by screw conveyors to an elevator and thence to a hopper-feeding device, which feeds so many pounds per hour to the hydration troughs. There are three of these, 36 ft. long x 3 ft. in diameter, open top, and each containing a horizontal revolving shaft with many projecting arms 20 in. long. Water, in amount proportional to the free carbide in the cyanamide as shown by chemical analysis, is sprayed in at the feeding end of the trough. The material becomes damp and is conveyed by the revolving agitator to the other end, by which time the material must be perfectly dry. The agitator, revolving at the rate of 50 r.p.m., conveys the material along the trough at the rate of about 50 ft. a minute. The acetylene liberated in the hydration building goes to waste. The reaction in the hydration trough is:

$$CaO + CaC_2 + 3H_2O = 2Ca(OH)_2 + C_2H_2$$

From the hydrating troughs the dry cyanamide is discharged into a screw conveyor, and carried through an overhead tunnel to the autoclave building, 300 ft. away to the south, there to be converted into ammonia.

Ammonia Gas Department

The principal building of this department is the autoclave building, but auxiliary apparatus is contained in the process boiler house and in the filter building, while the dephlegmators and steam condensers are out-of-doors, between the autoclave building and the process boiler house.

The latter must not be confused with the main power house, which was described at the beginning of this article. The process boiler house is to furnish steam for the autoclaves, also for heating the various plant buildings. It is located about 100 ft. to the east of the autoclave building. The equipment consists of four 825-hp. B. & W. Stirling type boilers, with the necessary feed-water pump and water-measuring apparatus. The boilers are fired by Westinghouse stokers from overhead bunkers. Coal is delivered to the boiler house on a track north of the building, and is dumped into a hopper beneath the track, and conveyed to a crusher, then elevated to the bunkers. The operating pressure of these boilers is 150 lb.

The autoclave building (81 ft. x 252 ft.) contains the autoclaves for the manufacture of ammonia from cyanamide. The autoclaves are cylindrical steel tanks, 8 ft. in diameter and 20 ft. high, each provided with a vertical agitator, which revolves at the rate of 12 r.p.m. throughout the continuance of the reaction. There are 56 autoclaves in all, made of 1¼-in. steel by M. W. Kellogg, New York.

The milled cyanamide, arriving at the autoclave building, is hoisted by a bucket elevator to an upper floor, and dumped into a steel silo. From this it is fed into 14 hopper bins, and these discharge into weigh bins. Each weigh bin feeds into a 5-in. screw conveyor, which in turn supplies a 12-in. screw, delivering to 4 autoclaves.

Before charging any cyanamide into the autoclave, a 2 per cent solution of caustic soda is run in to a depth of 9 ft. Then about 300 lb. of soda ash is added. Since the cyanamide carries about 13 per cent of free lime, the latter reacts with the soda ash to form some additional caustic soda, thus making the solution equivalent to 3 per cent in strength. After the addition of the soda ash the charge of cyanamide, 8000 lb., is admitted. The cyanamide, even after leaving the hydration building, still contains about 2 per cent of undecomposed calcium carbide, so that the first reaction in the autoclave, when the lime nitrogen comes in contact with the caustic soda solution, results in the generation of acetylene. All valves on the autoclave are closed except one, and through that one the acetylene is allowed to escape through an exhaust fan. After all of the acetylene has passed off, the outlet pipe is shut and clamped tightly. Then steam is admitted at a pressure of 150 lb. for 20 minutes. Ammonia gas begins to form in the autoclave. The reaction is exothermic. When the pressure in the autoclave rises to 250 lb., the ammonia escape valve is opened cautiously, but the pressure is maintained constant for 3 hours. By this time the pressure begins to fall off, and the ammonia is allowed to escape. The ammonia valve is closed again and steam is admitted a second time for 20 minutes. The reaction continues this time at 200 lb. pressure for an hour and a half. The chemical reaction in the autoclave is expressed:

$$CaCN_2 + 3H_2O = CaCO_3 + 2NH_3$$

This operation must be carefully controlled to prevent the pressure from rising too high, which would result in loss of valuable ammonia through the safety valves.

The gas escaping from the autoclaves (about 25 per cent ammonia and 75 per cent steam) goes to a header at the north end of the building, then to seven mud drums, then to seven dephlegmators, or ammonia columns. These are about 10 ft. in diameter and 25 ft. high, and each contains 16 horizontal plates. The gas enters at the bottom, and rising through 4-in. holes in the plates, covered with bell-shaped caps, bubbles through ammonia liquor standing on the plates or shelves. The gas then goes into 14 condensers (seven sets with two connected in series to each set). The condensers contain vertical tubes through which water circulates, and here the steam is condensed. The ammonia gas then goes to a 28-in. pipe, which is tapped by two 20-in. mains, one of which conveys 55 per cent of the ammonia to two 60,000-cu.ft. receivers, to supply the catalyzer plant, while the other carries 45 per cent of the gas to the neutralizer building. The capacity of the plant is 1000 tons of ammonia gas per week.

The Filter Room

A quantity of sludge, consisting chiefly of carbonate of lime, caustic soda, free carbon, etc., remains in the autoclave, and must be removed before recharging. An 8-in. outlet at the bottom of the autoclave permits the sludge to be blown out with steam or air. It flows by gravity to the filter room (151 ft. x 160 ft.) adjoining the autoclave building, where it is treated for the recovery of the caustic soda. In the filter room there are two sets of Oliver rotary filters, ten filters to a set. Each of the four sludge troughs feeds into five

filters which operate under a suction of 20 in. of mercury, produced by three vacuum pumps. The caustic soda solution, now reduced in strength to only 2 per cent, is sucked out, and the cake is scraped off into a conveyor and discharged to the sewer.

The filtrate goes through two tanks and is pumped by seven 650-gal. Gould centrifugal pumps to eight filtrate storage tanks containing cooling coils. From these it is drawn to seven filtrate measuring tanks, from which it is returned to the autoclave. It is in this filter room that the caustic soda solution coming from the scrubbing towers in the liquid-air building is brought up to strength. It is then returned to the nitrogen department.

Nitric-Acid Department

The nitric-acid department comprises the catalyzer buildings, the oxidation towers and coolers, and the absorption towers for making nitric acid.

There are six catalyzer buildings, each 50 ft. x 210 ft., and each consisting of two units. On the west side of each catalyzer building there is a meter room. Under the meter room is a 5½-ft. air duct fed by blowers located in the first meter room. Ammonia gas is drawn

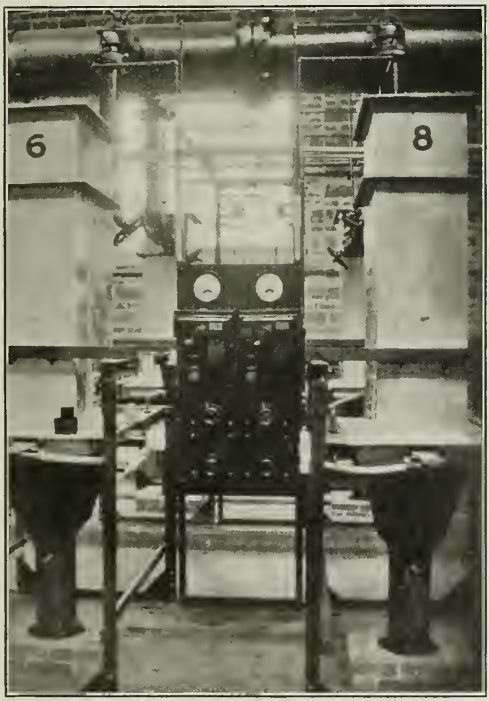


FIG. 3. CATALYZERS FOR OXIDIZING AMMONIA GAS

from the receiving tanks into which it was delivered from the ammonia-gas department, and by means of meters it is mixed with air in the proportion of 1:9 or 1:10. The mixture is passed into 12 steel mixing tanks (8 ft. in diameter x 30 ft. high) which are filled with 6-in. spiral rings. From the mixers the gas goes to the catalyzers.

In each catalyzer building there are four rows of catalyzers, 29 to a row, or 696 catalyzers in all. The photograph (Fig. 3) shows two catalyzers, with switchboard between, while Fig. 4 shows a row of catalyzers, with ammonia-feed pipe overhead and gas-discharge pipes leading out of the bottoms into a common flue. The catalyzers are spaced 5 ft. apart. The ammonia gas enters at the top through an iron pipe flanged to the aluminium casing, which is a rectangular box, 14 in. x 28 in. x 5 ft. high. At the base of the aluminium box there is a sheet of platinum gauze suspended in horizontal position. This gauze is made of $\frac{3}{1000}$ in. platinum wire, contains 80 meshes to the inch, and each sheet weighs 4.6 troy ounces. Each catalyzer has an 8-kw. transformer, and operates at 21 volts, stepped down from 460 volts, and 375 amperes. The platinum gauze is heated by the electric current to 750 deg. C. The ammonia gas, passing through the incandescent platinum gauze (which can be plainly seen through a small window in one side of the aluminium box) is converted into nitrogen oxides, and the converted gas escapes through a cast-iron pipe at the bottom of the catalyzer to a flue or tunnel made of concrete lined with chemical brick laid in acid-proof cement. These flues or tunnels convey the oxides of nitrogen to the oxidation towers and coolers.

The building for these towers and coolers is 100 ft. wide x 600 ft. long. There are 24 high-temperature coolers which are merely horizontal boilers supplied with steam at 25 lb. pressure. In these boilers the gas, passing through the boiler tubes, is cooled from 600 deg. to 200 deg. C. It then goes to 12 low-temperature coolers, through aluminium pipes 30 in. in diameter.

The low-temperature coolers consist of a rectangular chamber, divided into five compartments by four walls which do not reach entirely across the width of the chamber. The gas is thus caused to take a zigzag course through the chamber. Suspended from the top of the chamber are a large number of 5-in. tubes 7 ft. long—140 tubes to each of the five compartments. In two of the compartments the tubes are made of chemical stoneware, and in the three others of duriron, and each tube is provided with an outlet lip at the top. Inside each tube there is an inner tube, down which water flows. Escaping at the bottom of the inner tube, the water rises in the outer tube and escapes at the lip.

The gas is thus cooled to 30 deg. C. In these coolers nitric acid begins to form, and part of the nitric oxide becomes oxidized to nitrogen peroxide. The nitric acid formed is drained into No. 3 well of the absorption tower system. The gas, now a mixture of NO and NO_2, goes to the oxidation towers.

The Oxidation Tower

There are 12 oxidation towers, 15 ft. square, made of chemical brick. Each tower is divided by two walls into four equal compartments. The gas passes up one compartment, over the top of the dividing wall, down the next, through a hole at the bottom of the next wall, up the next compartment, over the wall, and down the last compartment. The gas is now practically all N_2O_4, and in this state passes on to the absorption towers.

The absorption-tower building (100 ft. wide x 600 ft. long) is located next to the oxidation towers, and to the

southeast of them. In this building there are twelve units of absorption towers, two towers to a unit connected in series. The structural steel for the towers is heavily coated with pitch, to protect it against corrosion. The towers, built of acid-proof brick laid in acid-proof cement, are 35 ft. square x 60 ft. high. Each tower is divided by interior brick walls into four compartments, as in the oxidation towers. The first tower of each unit is packed half way up with 6-in. spiral rings, and the upper half is packed with 3-in. spiral rings. The second tower of each unit is packed entirely with spiral

FIG. 4. VIEW IN CATALYZER BUILDING

rings of the 3-in. size. The gas from the oxidation towers passes into the first absorption tower of each unit, then into the second. In passing through the four compartments of each tower the gas pursues a course similar to that taken in the four compartments of the oxidation towers—up one compartment, down the next, and so on. Water is sprayed into the top of that compartment of the second towers of each unit last reached by the gas. From there on, the liquid pursues a course through the compartments of the two towers of each unit opposite to that taken by the gas, the liquid discharged from each compartment being used to feed to the top of the next forward compartment in the series. Thereby the liquid becomes progressively stronger in nitric acid as it passes from one compartment to another, until when it reaches the front compartment it has a strength of 50 per cent. The reactions in the absorption tower are expressed thus:

$$2NO_2 + H_2O = HNO_3 + HNO_2$$
$$HNO_2 + NO_2 = HNO_3 + NO$$
$$2NO + O_2 = 2NO_2$$

The pumping of the liquid is done by means of air lifts—a one-stage lift for each compartment of the 24 towers (96 in all) and 24 spares. To accommodate these lifts 120 wells, 12 in. in diameter and 100 ft. deep, were bored. The air lifts are made of 3-in. aluminium pipe, the lengths flanged together with duriron flanges. Air at 100 lb. is supplied to the air lift through a 1-in. pipe. The acid in that part of the air lift inside the well is cooled by water, constantly circulating into and out of the well. An electric signal system, connected to a signal lamp, will be provided for each well, for indicating any leakage of acid into the cooling water. On account of the low conductivity of pure water, the lamp will remain dark as long as there is no acid escaping, but the moment the least leakage occurs the acidulated water becomes a good conductor and the signal lamp becomes luminous.

The acid is pumped to the top of each compartment to a separator, where the air escapes. Then the acid goes to a distributor box, then to sprayers on the top of the tower.

Between the first and second towers of each unit there is an aluminium exhaust fan drawing the gas from the first tower and forcing it through the second. After the second tower of each unit there is another aluminium fan which discharges the residual gas into the atmosphere. The acid outlets for the towers are of 4-in. duriron pipe, flanged to the 3-in. aluminium air lift.

The final product of the towers is delivered to 12 aluminium weighing tanks (about 10 ft. in diameter and 12 ft. high) on scales, and is then discharged into 12 storage tanks, 25 ft. in diameter and 10 or 12 ft. high, made of concrete and lined with acid-proof brick. From the storage tanks the acid is drawn off by a 3-in. aluminium siphon to a 4-in. duriron header which conveys the acid to the next department.

The Nitrate Department

There are two branches of the nitrate department: (1) The neutralizing building, where the nitric acid is neutralized with ammonia gas, and (2) the crystallizing buildings.

In the neutralizing building (93 ft. wide x 150 ft. long) there are four absorbing towers with two mixing tanks, four condensers, four neutralizing tanks, four settling tanks, one receiving tank and three filter presses. There are also eight settling tanks located outside the building.

The nitric acid comes from the storage tank to the mixing tank, then by means of an air lift is elevated to the top of the absorbing towers. The latter are 7 ft. square x 20 ft. high, packed with 3-in. spiral rings. The unabsorbed ammonia gas from the neutralizing tank (see below) passes up these towers. From the bottom of the tower the liquid goes to the mixing tank; from this tank it is pumped to a distributing pot on top of the tower and from that it is drawn off to the neutralizing tank. The liquid still has an excess of nitric acid.

The Neutralizing Tank

In the neutralizing tank there are four 10-in. inlets for ammonia gas at the top. There is always about 3 ft. of liquid in the tank, so that the ends of the ammonia pipes, projecting through the top, are immersed in the liquid and the ammonia gas is forced to bubble through. The nitric acid is thus neutralized and ammonium nitrate, in solution, is formed. The reaction is:

$$HNO_3 + NH_3 = NH_4NO_3$$

The unabsorbed ammonia gas passes through a condenser which is like the low-temperature gas cooler for the gases leaving the catalyzers, only much smaller, then passes through the absorbing tower, where it meets nitric acid as previously described.

The ammonium nitrate solution goes from the neutralizer to storage tanks, then to the settling tanks. From time to time the sediment is taken out and put through the Sperry filter press. The filtrate goes to the filtrate tank and is re-treated. The final settling is done in eight ammonium nitrate tanks, where the liquor is stored for the next process—crystallization.

There are five ammonium nitrate or crystallizer buildings, each 60 ft. wide x 120 ft. long. They are all located 500 ft. apart and 500 ft. from any other building, as a precaution against explosion or fire. Being the scene of the last operation in the process, they are located at the southern extremity of the nitrate-plant site. Each building is supplied by a 6-in. pipe for ammonium nitrate solution, a 6-in. steam pipe, a 2½-in. compressed-air pipe, and a 2½-in. pipe for ammonia gas for completing neutralization in case the liquor should come up slightly acid.

Evaporating Pans

Each building has a storage tank for nitrate liquor (10 ft. in diameter x 12 ft. high) and ten evaporating pans, coated on the inside with a blue-enameled lining. These pans are 11 ft. long x 6½ ft. wide x 2¾ ft. deep. The pure nitrate solution is pumped to the crystallizer building, and from the storage tank there is drawn into the evaporating pans. The evaporation is accomplished by means of steam pipes. There are in each evaporating pan six 3-in. aluminium steam pipes, extending the full length of the pan and back again. Each evaporating pan is also equipped with three ½-in. air pipes, also of aluminium, which are used for agitating the liquid by means of compressed air, to facilitate evaporation. Over each pan there is a hood and flue for carrying away the fumes. Each pan is set up on six pedestals 2½ ft. high, so that the top edge of the pan is nearly 5 ft. from the floor, with ample air space underneath.

Each pan drains into two open-top crystallizing kettles, each 6 ft. in diameter x 2 ft. 2 in. deep, jacketed, and piped in such a way that they can be either steam-heated or water-cooled. They are also provided with an agitator, which revolves at the rate of 17 r.p.m.

The nitrate liquor is evaporated in the pan to the crystallizing point. It is then withdrawn at a temperature of 145 deg. C. from the pan to the kettle, where at first it is heated by means of steam in the jacket, so as to cool it gradually; then the steam is shut off and cooling water is admitted to the jacket while the agitator continues to revolve, and the ammonium nitrate crystallizes out in the kettle. A gate on the side of the kettle is opened and the agitator sweeps out the crystals on to a clean floor.

In appearance the ammonium nitrate is much like coarse-grained common salt. It is shoveled down through a hole to a lower floor, and is packed for shipment. The capacity of the five buildings is to be 300 tons of ammonium nitrate per day.

Water System

All water used in the chemical processes of this plant, as well as water for domestic and fire protection purposes, will be pumped from the main power house. For this purpose four 18-in. Allis-Chalmers centrifugal pumps, each with a capacity of 9730 gal. per minute, under a head of 200 ft., will be used. The water discharged from these pumps will be carried through two 36-in. cast-iron pipe lines running parallel from the power-house to the summit of the bluff to the south, about 3500 ft. away, thence through a 72-in. reinforced-concrete duct by gravity about 600 ft., into a settling and storage reservoir. This reservoir has a capacity of 60,000,000 gal., and has a settling area, when full, of 900,000 sq.ft. The water for the process may be taken direct from the reservoir through 36-in. reinforced-concrete pipe into cast-iron mains, or it may pass through the pumping station if more pressure is required. This station contains four 18-in., 9730-g.p.m. centrifugal pumps driven by 500-hp. motors, delivering into the process mains. The water for domestic purposes will be treated and filtered at the filtering plant just below the level of the reservoir and will discharge into the pumping station, where it will be handled by two 4-in. centrifugal pumps of 300-g.p.m. capacity each, driven by 25-hp. motors, and two 5-in. centrifugal pumps of 750-g.p.m. capacity, driven by 50-hp. motors. In this pumping station there will also be two 8-in. centrifugal fire pumps of 1500-g.p.m. capacity, each driven by a 100-hp. motor.

Long as the above description may seem, it does not by any means do justice to the plant. To cover adequately all the details of the process a volume could be written on each of the ten departments. This brief survey merely calls attention to the more important parts of the equipment and touches on the vital features of the process. It is difficult for any one who has not seen the plant to realize its magnitude—to grasp that there is at Muscle Shoals a huge plant of ten departments, any one constituting a large plant in itself, and the ten combined giving employment, when operating at full capacity, to between 3000 and 4000 men. The construction up to Nov. 15, 1918, and then incomplete, was said to have cost $60,000,000.

Built in Less Than a Year

The principal contractors for the plant have been: (1) The J. G. White Engineering Corporation, New York, in charge of power-house installation complete, bus-tunnel line and process-pipe lines (36 in.) for the water reservoir; (2) Westinghouse, Church, Kerr & Co., New York, in charge of erection of plant buildings, etc.; and (3) Chemical Construction Co., responsible for the construction and installation of much of the chemical equipment, such as towers and their accessories, coolers, gas flues, tanks, etc.

On Nov. 25, 1918, individual units were operating in every building as far as the lime-nitrogen-mill building, the product having reached that point on its way through the process. Units in all the other departments were being tuned up and dried out. The power in use, only 5000 kw., was being delivered to the plant by the Alabama Power Co. It was expected that by the latter part of December the plant would be operating at the rate of 30,000 kw. (33⅓ per cent capacity); by Jan. 1, 1919, at the rate of 50,000 kw. (45 per cent capacity); and by Feb. 1, at the rate of 90,000 kw., or full capacity. If this schedule is adhered to, the plant will be in full operation in less than one year from the date of first breaking ground.

Exhaust Steam at High Back Pressures

A System of Charts Based on Thermodynamical Formulae and Data with Reference to Boiler Pressures and Cutoffs—Description of an Eight-Ton Dye Plant Operation Using Steam Jacketed Evaporating Pans, Vacuum Driers, Kettles and Chambers

BY CROSBY FIELD

STEAM as exhausted from an engine contains approximately 85 per cent of the amount of heat contained in the steam supplied to the engine. This fact has long been recognized and attempts have been made to utilize exhaust steam for many industrial purposes, but due to the high temperatures used in the dyestuff and other similar chemical industries full value of the exhaust steam has not been attained therein.

The object of this paper is to provide a set of charts from which the plant engineer can very rapidly determine just what back pressure would be the economical one for him to use provided the chemical processes involved do not require a higher temperature than that provided by this back pressure. A method is also suggested whereby the plant engineer may use some of this exhaust steam when the process requires a temperature too great for exhaust steam at the economical pressure.

The pressures to which exhaust steam can economically be carried are very much higher than is usually thought. For several years past the writer has very successfully used back pressure at 50 lb. per sq.in. gage and under some conditions has used 80 lb. per sq.in. gage. This is accomplished with absolutely no deleterious effect upon the machinery.

It is not to be assumed that the writer believes that high back pressures are universal panacea, but he does believe that they should be used much more than they have been in the past.

EXPLANATION OF CHARTS

Instead of dealing with these subjects theoretically and including a large number of interesting formulæ, which the plant engineer will probably never have the time to investigate, the accompanying charts used by the writer in his practice are given, and in addition examples of their use. In referring to these it must be remembered that:

They are all based on the theoretical expansion curve of steam, i. e.,

$$P_m = p_i \frac{1 + \text{hyp. log. } R}{R}$$

or $P_m = P_t\ (1 + \text{hyp. log. } R)$

wherein

P_m = absolute mean pressure

p_i = absolute initial pressure considered uniform up to cutoff

P_t = the terminal pressure

R = ratio of expansion.

They are not offered as accurate scientific work, but merely as being charts found of value to the writer and of sufficient accuracy to warrant their continued use. It is believed that these approximate all of the commercial cutoffs. It must be remembered that they are purely theoretical curves and give an approximation only of actual conditions. It is believed, however, that in most cases these curves will solve the problem to an accuracy of from 5 to 10 per cent, which is sufficiently close for the plant engineer, as the inaccuracy due to the differences of operation at various times will usually more than offset this.

On both the sets of curves from Figs. 2 to 12 inclusive, an additional scale has been run giving the theoretical increase in the weight of steam used for the same power due to the increased back pressure, so that all needed quantities can be read off of the chart at once. Fig. 13 is necessary when it is desired to solve complicated cases which cannot be readily solved by a single reading of the previous charts.

EXAMPLES—USING CHARTS

For illustration, assume a color plant producing 500,000 lb. total of several colors per month, containing the following chemical apparatus:

20 Evaporating pans,
10 Vacuum driers,
20 Jacketed cooking kettles,
5 Air blast dry rooms,
Large number of tube containing materials boiled by injection of live steam through pipes, etc.

Upon closer investigation, the following summary presents itself:

SAMPLE SUMMARY SHEET OF STEAM CONSUMPTION IN DYESTUFF PLANT

Item	Apparatus	Number	Temp. of Product Deg. F.	At Present Supplied by	Remarks
1	Evaporating pans	15	214	Boiler steam through reduction valve to 35 lb.	This pressure is as high as can be used satisfactorily in order to prevent boiling over.
2	Evaporating pans	5	214	Boiler steam through reduction valve to 5 lb.	
3	Vacuum driers	5	?	Boiler steam through reduction valve to 3 lb.	This pressure cannot be raised due to danger of burning product
4	Vacuum driers	5	?	Boiler steam through reduction valve to 40 lb.	
5	Cooking kettles	10	230	Boiler steam through reduction valve to 80 lb.	
6	Cooking kettles	5	240	Boiler pressure	
7	Cooking kettles	5	260	70 lb.	
8	Air blast dry room	5	100 to 180	Boiler pressure	

The above apparatus consumes an average of 50,000 lb. of steam per hour and 700 kw.-hrs. per hour. Assuming this latter equivalent to 29,000 lb. (see below), the total steam required is 79,000 lb. per hour.

Item 1 can be operated on a pressure of 35 lb. or over, item 2 on a pressure of 5 lb. or over, item 3 on a pressure of 3 lb. or over, item 4 on a pressure of 40 lb. or over, item 5 on a pressure of 40 lb., by adding addi-

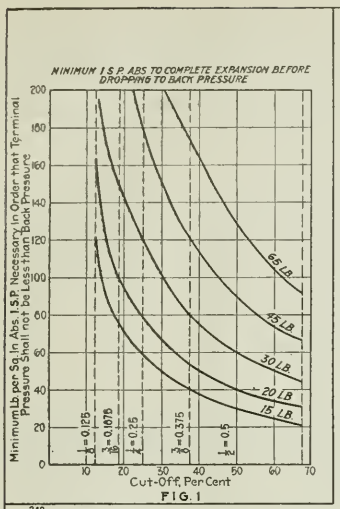


FIG. 1

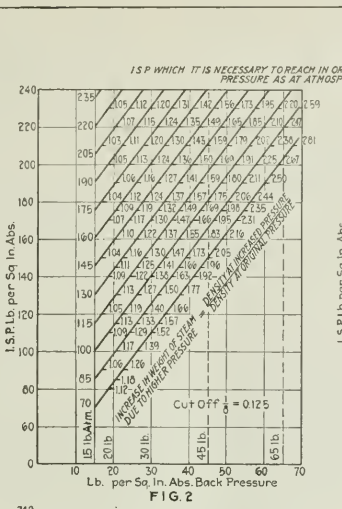


FIG. 2

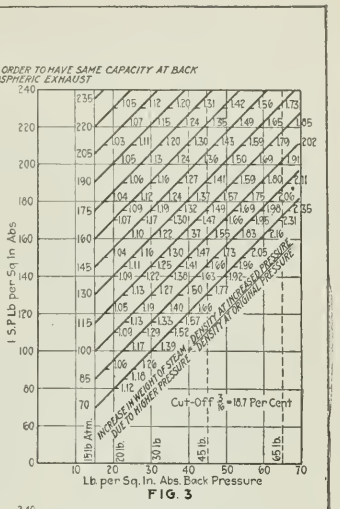


FIG. 3

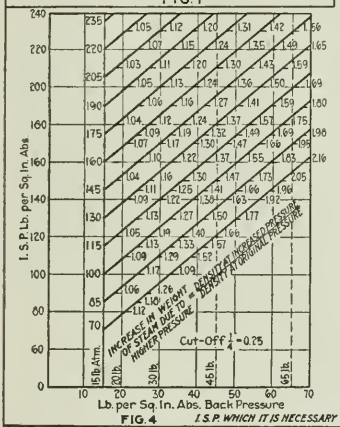


FIG. 4

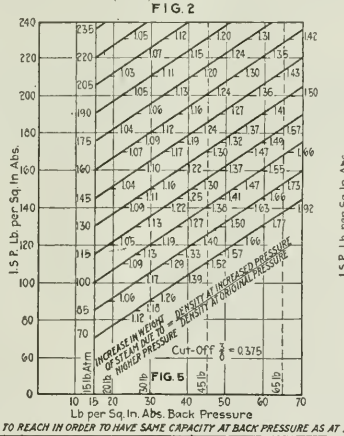


FIG. 5

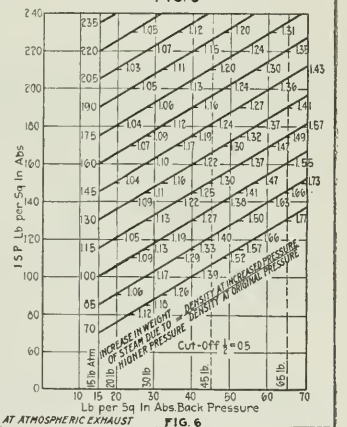


FIG. 6

I.S.P. WHICH IT IS NECESSARY TO REACH IN ORDER TO HAVE SAME CAPACITY AT BACK PRESSURE AS AT ATMOSPHERIC EXHAUST

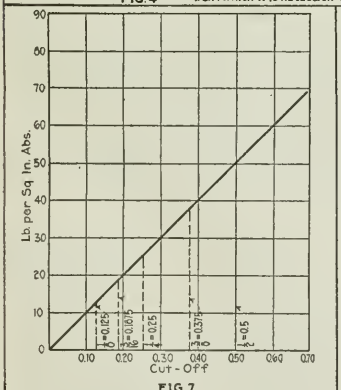


FIG. 7

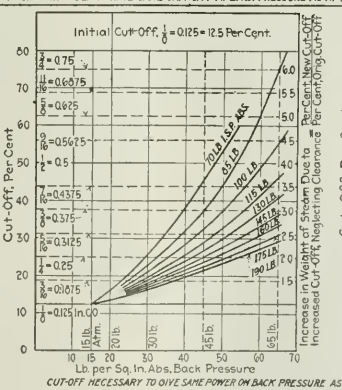
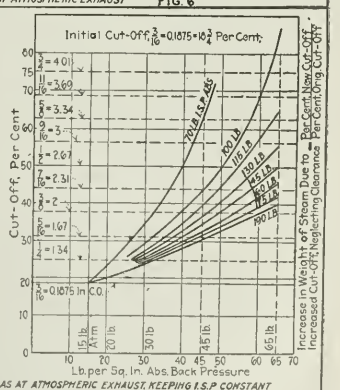


FIG. 8



CUT-OFF NECESSARY TO GIVE SAME POWER ON BACK PRESSURE AS AT ATMOSPHERIC EXHAUST, KEEPING I.S.P CONSTANT

FIG. 9

tional heating surface in form of coils to an amount as given by the formula

$$\frac{Ts \text{ at } 80 \text{ lb.} - T_P}{Ts \text{ at } 40 \text{ lb.} - T_P} - 1 = \frac{324 - 230}{287 - 230} - 1 = 65 \text{ per cent}$$

where Ts represents the temperature of steam and T_P the temperature of product.

Item 6 can be operated on a pressure of 40 lb. by adding additional heating surface in form of coils equal to:

$$\left(\frac{Ts \text{ at boiler pressure} - 240}{Ts \text{ at new back pressure} - 240} - 1\right) \times 100 = \text{per cent}$$

more.

Item 7 cannot be operated on any reasonable back pressure, hence a special line must be run here from the boiler pressure service mains. A test made by measuring the drip discharges from these apparatuses, however, gives a total value of steam consumed this way of only 3000 lb. per hour.

Item 8 can be run on 40 lb. by adding additional heating surface.

From Fig. 4 the necessary initial steam pressure to give same power on 65 lb. back pressure as on 105 lb. absolute exhausting to atmosphere is 185 lb. and the increase in weight of steam is 1.7. This can also be calculated from the steam tables, when increased steam weight will be proportional to increase of density

$$\left(\frac{4.24}{2.48} = 1.7\right).$$

Steam supplied engines at 185 lb. = 29,000 × 1.7	49,300
Steam condensed by expansion (Fig. 14), (Molier chart), (100 per cent — 93 per cent)	7 per cent.
Condensation losses	6 per cent
Total losses	13 per cent
Steam returned to factory by engines at 65 lb., 49,300 × (100 per cent — 13 per cent)	43,000
Steam required by factory at 65 lb.	47,000
Deficit to be made up by reduction value	4,000
Required by factory at 185 lb.	3,000
Total steam supplied by boilers at 185 lb., 49,300 + 4,000 + 3,000	56,300

Per cent saved, $\frac{79{,}000 - 56{,}300}{79{,}000} = 29$ per cent

This permits shutting down the 20 per cent low pressure boiler plant for economy. Thus by increasing the pressure on one bank of boilers we have succeeded in wholly eliminating the use of the other, thanks to high back pressure exhaust.

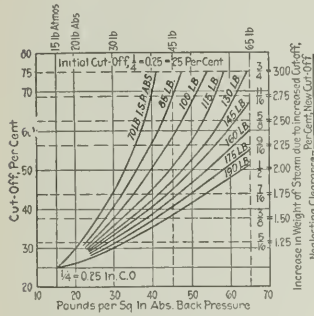


FIG. 10

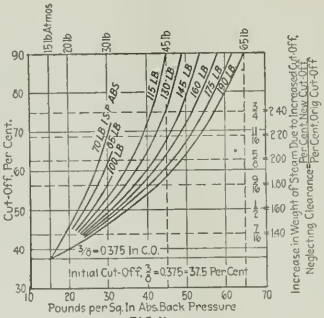


FIG. 11

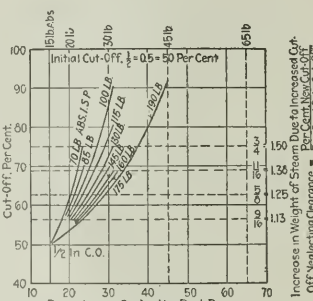


FIG. 12

CUT-OFF NECESSARY TO GIVE SAME POWER ON BACK PRESSURE AS AT ATMOSPHERIC EXHAUST, KEEPING I.S.P. CONSTANT

In order to illustrate the various use of the charts and calculations, three different conditions of the power plant will be assumed:

Case A—High back pressure obtainable by increasing initial steam pressure.

Case B—High back pressure obtainable by increasing cutoff of reciprocating engines.

Case C—High back pressure obtainable only by combination of the above.

Case A

High back pressure obtainable by increasing initial steam pressure: Assume a plant in which one-fifth of the total horsepower consists of H.R.T. boilers having a safe pressure of 100 lb. gage and the balance of water tube boilers having a safe pressure of 175 lb. gage. The average working pressure is therefore 90 lb. gage.

This case is typical of several plants which started to install high pressure boilers, but due to long deliveries and too rapid increase in production had to purchase something quickly, hence filled in with the low pressure H.R.T.'s.

Boiler pressure 400 kw. of Corliss engines at 35 lb./kw.-hr.	14,000
300 kw. slide valve engines at 50 lb./kw.-hr.	15,000
Hourly steam demand at atmospheric exhaust	29,000

Cut off from indicator cards = ⅛.

Case B

High back pressure obtainable by increasing cutoff of reciprocating engines: Boiler pressure on engines, 130 lb. Allowable boiler pressure, 140 lb.

Plant averages 400 kw. of Corliss engines at 35 lb. per kw.-hr	14,000
300 kw. of slide valve engines at 50 lb. steam per kw.-hr	15,000
Total average hourly steam demand for power	29,000

Cutoff from indicator cards = ⅛ (0.187 = 18.7 per cent)
130 lb. gage = 145 lb. absolute.

From Fig. 9:

Absolute Back Pressure, Lb. per Sq. In.	Cutoff for Same Power	Approximate Increase in Weight of Steam for Same Power
15	18.7	0 00
30	26.0	1.46
45	35.0	1.80
55	43.0	2.20
65	49.0	2 60

APPROXIMATE HIGHEST BACK PRESSURE TO UTILIZE ALL OF THE EXHAUST STEAM

	Per Cent.
Average expansion loss (equals moisture in steam at exhaust pressure, assuming dry and saturated at initial pressure can be read directly from Molier diagram, Fig. 14)	6
Average condensation losses	6
Total	12
Allow	3
Total	15

Steam consumption of factory which might be used on low pressure (15 to 65 lb.) = 50,000 — 3,000 = 47,000.

Steam consumption of engines = 29,000.

Proportion factory to engine consumption = $\frac{47,000}{29,000}$ = 1.62.

Adding 15 per cent for losses, factor becomes 1.62 × 1.15 = 1.87.

Most Economical Back Pressure

From Fig. 9 we see that the most economical back pressure is at the point of intersection of the ratio, value of 1.87 with the curve for 145 lb. = 45 lb. absolute back pressure (= 30 lb. gage) and 35 per cent cutoff. If sufficient additional heating surface can be put in the chemical apparatus to compensate for this reduced steam pressure, the problem is solved, the saving being approximated as follows:

Steam supplied to engines at 145 lb., 29,000 × 1.87	53,400
Loss due to expansion (Molier diagram, Fig. 14), (100 per cent — 92 per cent)	8 per cent
Loss due to condensation	6 per cent
Total loss	14 per cent
Steam supplied by engines to factory at 45 lb., 53,400 × (100 per cent — 14 per cent)	47,000
Steam demanded by factory at 45 lb., 50,000 — 3,000	47,000
Total steam supplied engines by boilers at boiler pressure	53,400
Total steam supplied factory by boilers for item 7	3,000
Total steam supplied factory by boilers under new conditions	56,400
Total steam supplied factory under original conditions	79,000
Saving	22,600

Per cent saving, $\frac{22,600}{79,000}$ = 28.6 per cent

Steam now chargeable to power, 53,400 × 14 per cent	7,400
Steam formerly chargeable to power	29,000
Saving	21,600

Per cent saving, $\frac{21,600}{29,000}$ = 74½ per cent

The method of attack when back pressure as found above is too low for the factory demands will be described below. Let us now examine the question of what pressure is necessary for the factory.

This is usually fixed by the highest temperature of product. The best way to proceed is to ascertain both by inquiries from the chemist and plant foreman and personal investigation just what is the highest temperature at which the products must be maintained. Also note whether the kettles are connected to a high or low pressure main and what is the average steam pressure at the jacket. Although the temperature drop and the heat transmission have been thoroughly investigated theoretically, yet the various differences in condition of heating surfaces and nature of materials renders proper application of the theoretical results difficult. The writer is doing a considerable amount of research on this point and may have results to publish later. For the present he has found a 50 deg. F. temperature drop to be sufficient in almost every case. Consequently the highest temperature of the product plus 50 deg. will give the temperature of the steam required in the jacket from which the necessary back pressure may be established. Having established this, the question of sizes of pipe and general steam calculations become easy.

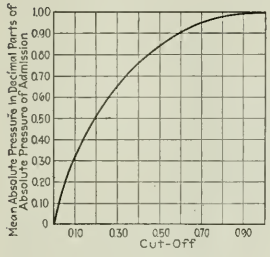


FIG. 13

STEAM ENGINE RATIOS

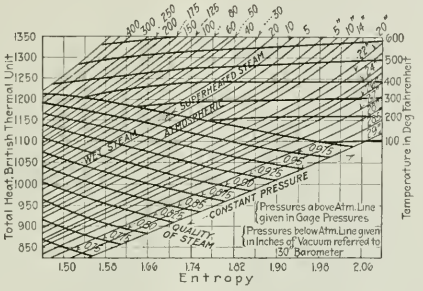


FIG. 14

MOLIER DIAGRAM

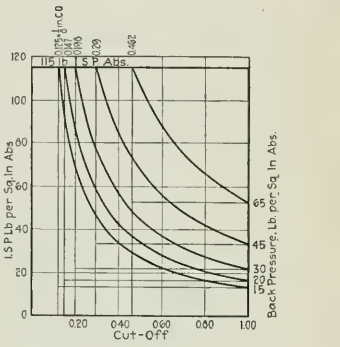


FIG. 15

EXPANSION CURVES SAME POWER AND I. S. P.

In special cases the value of the back pressure necessary may be determined by the economical pressure for the design of evaporating and cooking apparatus. Remembering that the rate of evaporating varies proportionately with the temperature differences and noting from the following table:

Pounds per Inches Abs.	Steam Temp., Deg. F.	Temp. Drop	B.t.u.'s per Sq. Ft. per Hour	Lb. Water Evaporated per Hour
15	212	0	0	0
20	228	16	8,000	8.4
30	250	38	19,000	19.6
45	275	63	32,000	33.0
65	298	86	43,000	44.5
70	303	91	. . .	. .
85	316	104	. . .	. .
100	328	114	. . .	. .
115	338	126	. . .	. .
130	347	135	. . .	. .
145	356	144	. . .	. .

We see, if we assume the case under consideration to be that of evaporating in an open vessel, that at a 50-lb. back pressure a given apparatus would do more than five times the work it would do at a 5-lb. back pressure, and similarly that a 50-lb. back pressure and a given apparatus would do about 70 per cent of the work it would do at a 100-lb. pressure.

The matter of the coefficient of heat transmission is a matter of conjecture varying greatly with the different conditions of evaporation. Theoretically the coefficient of heat transmission for iron is 233 B.t.u.'s per square foot per hour per degree temperature difference per inch in thickness. As evaporating and cooking apparatus is rarely over ¼-in. thick, this will give us approximately 900 B.t.u.'s per square foot per hour per Fahrenheit degree difference of temperature. Because

of the above variable conditions a good all around average value is 500 B.t.u.'s per square foot per hour per degree difference of temperature. This coefficient for heat transmission does vary greatly with pressure, according to Kerr in his article in the July, 1916, issue of the *Journal of the American Society of Mechanical Engineers*, page 545:

"Let V = coefficient of heat transmission in B.t.u.'s per square foot per hour per degree Fahrenheit, and let D = density of the heating steam in pounds per cubic feet, then: V = 225 + 17,500 D."

On the other hand, in a writers' discussion by Dr. Orrok, comparison was made with Parr's formulæ, where

$$V = 1290\sqrt{PD}$$

where P = absolute pressure in lb. per sq.in.

scale of Fig. 9, but may be calculated as follows: Assuming 65 lb. back pressure and 49 per cent cutoff we get the increase in weight of steam by engines = $\frac{49}{18.7}$ = 2.6

Hourly steam demand for power at 65 lb., 29,000 × 2.6	76,000
1 lb. steam expanding from 145 to 65 lb. will be (Molier diag. Fig. 14), 94 per cent dry at latter pressure	
Loss due to moisture (expansion), 100 — 94 per cent	6 per cent
Assuming 6 per cent condeosation loss	6 per cent
Total loss	12 per cent
Steam supplied by engines at 65 lb. to factory, 76,000 × (100 per cent — 12 per cent)	67,000
Steam required by factory at 65 lb	47,000
Excess steam supplied at 65 lb	20,000
Total steam under atmospheric conditions—power	29,000
Total steam under atmospheric conditions—factory	50,000
Total steam under atmospheric conditions, power-factory	79,000
Total steam under 65 lb. back pressure conditions, power-factory	76,000
Total steam factory at boiler pressure	3,000
Total steam from boiler under 65 lb. back pressure conditions	79,000

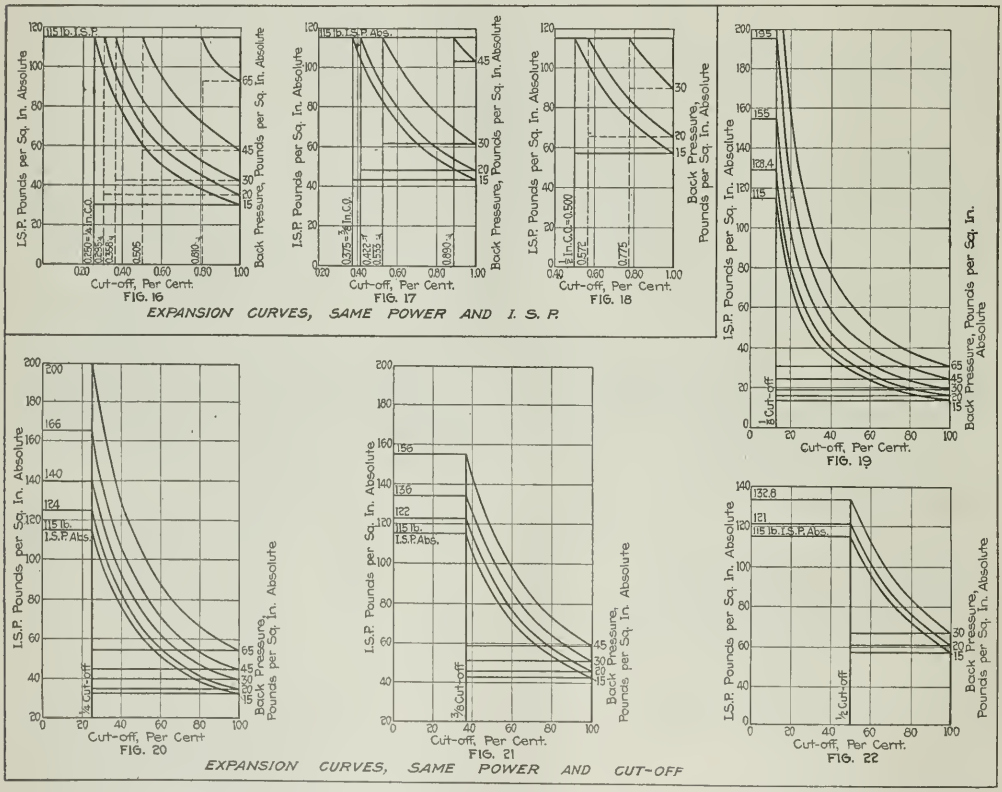


FIG. 16 FIG. 17 FIG. 18 FIG. 19 FIG. 20 FIG. 21 FIG. 22

Even with the lowest values by these formulæ, steam at 8-lb. gage pressure gives a coefficient V = 1200, which is too high and never reached in practice. The writer uses 500.

Method of Attack When Economical Back Pressure Cannot Be Used Because of Factory Conditions of Temperature

Assume a back pressure of 65 lb. absolute (equals 50 lb. gage) necessary for temperature conditions. The increase in steam will be approximately directly as the increase in cutoff. This is given as the ratio ordinate

Evidently for these conditions the gain is 20,000 lb. of steam for heating feed water at 65-lb. back pressure or for additional production, which in many ways would be well worth while. This system provides great capacity for heavy factory steam demand, as it could be said that there were 20,000 lb. of steam each hour which could be automatically diverted to the feed water heater or into the factory. It might be better, however, to run half the Corliss engine units (200 kw.) on an atmospheric feed water heater. The calculations then become:

200 kw. Corliss engines at 35 lb. kw.-hr.	7,000
300 kw. slide valve engines at 50 × 2.6	39,000
200 kw. Corliss engines at 35 × 2.6	18,200
Steam supplied to engines at 145 lb.	64,200
Steam delivered by engines to factory at 65 lb., (39,000 + 18,200) × 0.88.	50,300
Steam required by factory at 65 lb.	47,000
Excess for feed water heating and balance	3,300
Steam supplied engines	64,200
Steam supplied factory, at 145 lb.	3,000
	67,200

Saving of this system, $\frac{79,000 - 67,200}{79,000}$ = 15 per cent + 3,300 lb. for feed-water heating.

Amount chargeable to power, crediting power with 65 lb. feed water = 64,200 — (39,200 + 18,000) × 0.88 = 13,900.

Percentage of former amount $\frac{13,900}{29,000}$ = 48 per cent.

Amount chargeable to power, not crediting power with 65 lb. feed water = 64,200 — 47,000 = 17,200

Percentage of former amount, $\frac{17,200}{29,000}$ = 59 per cent.

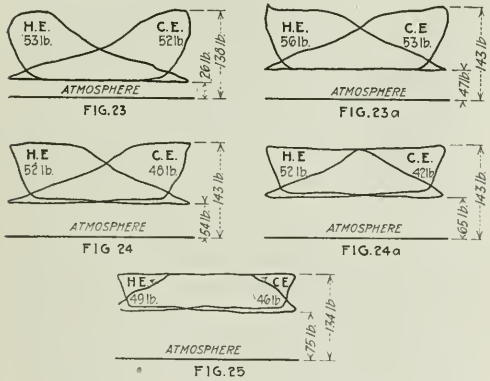
Case C

High back pressure obtainable only by combination of increased initial steam pressure and longer cutoff:

Working boiler pressure, 115 lb. gage equals 130 lb. abs.

Allowable boiler pressure, 150 lb. gage equals 165 lb. abs.

For same capacity and engine cutoff of ¼, from Fig. 4 the allowable back pressure will be increased from 15 lb.



FIGS. 23 TO 25. SOME SAMPLE INDICATOR CARDS TAKEN FROM AN ENGINE WORKING UNDER USUAL CHEMICAL PLANT NEGLECTFUL CONDITIONS, BUT WELL ILLUSTRATING THE ACTION AT VARYING BACK PRESSURES (FIGURES WITHIN THE DIAGRAMS ARE MEAN EFFECTIVE PRESSURES)

absolute to 33 lb. absolute by increasing the boiler pressure from 130 to 160 abs.

Ratio, $\frac{\text{Mean Absolute Pressure}}{\text{Initial Steam Pressure}}$ for 25 per cent cutoff = 0.586 (Fig. 13).

Mean absolute pressure = 160 × .586 = 93.8.

New back pressure (absolute) = 65 lb.

New mean absolute pressure = 93.8 + (65 — 33) = 125.8.

New ratio = $\frac{125.8}{160}$ = 0.785

New cutoff (Fig. 13) = 43 per cent.

Weight of steam per hp. will increase as its density, hence at 160 lb. will be $\frac{3.46}{2.84}$ = 1.22 times its weight at 130 lb. It will also increase directly as the percentage cutoff (neglecting clearance), hence at 43 per cent cutoff will be $\frac{43}{25}$ = 1.72 times its weight at 25 per cent cutoff. The total increase in weight of steam therefore will be 1.72 × 1.22 = 2.10. This value is high, because of the assumption made.

One lb. of steam expanding from 160 to 65 will be 94 per cent dry (Molier chart, Fig. 19) at the latter pressure. Allow a value of 6 per cent for cylinder condensation and leakage losses, and we have:

Total steam delivered by boilers to engines at 160 lb. pressure, 2.1 × 29,000	60,800
Total steam delivered by engines to plant at 65 lb., 2.1 × (0.94 — 0.06) × 29,000	53,500
Steam chargeable to power	7,300
Percentage of steam formerly used for power, $\frac{7,300}{29,000}$ = 25 per cent	
Total steam required by factory at 65 lb., 50,000 — 3,000	47,000
Total steam delivered by engines at 65 lb.	53,500
Excess steam for feed water heating at 65 lb	6,500
Steam required by factory at boiler pressure for item 7 (115 lb. gage—atmospheric)	3,000
Total steam under old conditions, 50,000 + 29,000	79,000
Total steam under new conditions (145 lb. gage to 50 lb. gage), 60,800 + 3,000	63,800
Saving in total steam, new as compared to old conditions	16,200

Per cent saving, $\frac{16,200}{79,000}$ = 21 per cent

Other Savings

When electricity is bought the substitution of cheap slide valve engines will often show a remarkable saving, when all the exhaust steam can be utilized in one of the ways shown above. For example, assume electricity at 2 cents per kw.-hr. and steam at 25 cents per 1000 lb.: Steam per kw.-hr. through engine, 50 × 1.75 = 87.5 lb. Steam used for power per kw.-hr., 87.5 × 0.12 = 10.5 lb.

Cost of steam per kw.-hr., $\frac{25 \times 10.5}{1000}$ = 0.262 of 1 cent.

Saving in power bill, $1 - \frac{0.262}{2000}$ = 87 per cent, which must be decreased by wages of engine room force, oil and supplies and interest and depreciation on engines (but engine room alone—*not* boilers).

Fifty pounds is sufficient pressure to run steam-driven duplex pumps under average conditions met in chemical plants. Where this does not result in sufficient pressure, a cheap remedy is to introduce liners in the liquid cylinders of the pump.

Superheat—Theoretically the ideal superheat to use is just sufficient to provide dry and saturated steam after expansion in the engines. Usually this means a total temperature of 550 deg. F. to 600 deg. F. As the average chemical plant is not operating with superheat to-day, no example is here given, but same can be readily solved by means of the charts.

Additional Cost of Increased Pressure

In some of the above examples the solution involves a slight increase of boiler pressure. Although theoretically this implies a corresponding increase in coal burned, yet experience has shown that this factor, if present, is so negligible as to be indistinguishable. In other words, no more coal is burned, in testing under normal plant conditions, to deliver one pound of steam at the higher pressure than at the lower, within the limits above indicated.

In 1915 one of the writer's plants was confronted with the following problem:

Three 200-hp. H. R. T. boilers good for a maximum

pressure of 150 lb. gage were supplying the factory. Due to the large amount of steam required, they were unable to maintain the pressure of 125 lb. The factory pressure was normally between 60 and 90 lb. It was also supplied with 150-hp. boilers, good for a maximum pressure of 90 lb. gage. The proposal was made to combine these with the H. R. T. boilers and run in that unsatisfactory way at about 85 lb. gage.

Instead of this a back pressure of 40 lb. per sq.in. gage was decided upon and the three high pressure H. R. T. boilers were operated at a pressure of about 140 lb. The 90-lb. boilers were used when necessary to make up for extra load through a reduction valve to bleed low pressure steam into these 40 lb. back pressure mains. Since that time the load on the boilers has been increased nearly three times, and although hand fired the high pressure mains vary between 125 and 140 lb., averaging 135 lb., and the low pressure mains are held practically constant at 40 lb. The result has been a great economy of fuel, ability to operate not only when lack of boiler capacity apparently prevented operation, but also after a considerable increase in the chemical apparatus load. A saving of many thousands of dollars has been accomplished.

Summary

The charts show very clearly the great advantages of having as high as possible initial steam pressure, and furthermore indicate the way to increase the present steam pressure by adding higher pressure units gradually, retaining the lower pressure to assist the back pressure exhaust system.

The higher the initial steam pressure the higher back pressure may be, with smaller pipes and less cost for installation of both. A comparison of pipe sizes is given below:

COMPARISON OF PIPE SIZES

40 lb. gage back pressure requires a pipe	7.82 / 23.80	or 32.9 per cent. of pipe required for 2 lb.
40 lb. gage back pressure requires a pipe	7.82 / 19.45	or 40.2 per cent of pipe required for 6 lb.
40 lb. gage back pressure requires a pipe	7.82 / 3.89	or 203 per cent of pipe required for 100 lb.
40 lb. gage back pressure requires a pipe	7.82 / 3.12	or 251 per cent of pipe required for 130 lb.
40 lb. gage back pressure requires a pipe	7.82 / 2.84	or 277 per cent of pipe required for 145 lb.
50 lb. gage back pressure requires a pipe	6.68 / 23.80	or 28 per cent of pipe required for 2 lb.
50 lb. gage back pressure requires a pipe	6.68 / 19.45	or 24.3 per cent of pipe required for 6 lb.
50 lb. gage back pressure requires a pipe	6.68 / 3.89	or 172 per cent of pipe required for 100 lb.
50 lb. gage back pressure requires a pipe	6.68 / 3.12	or 214 per cent of pipe required for 130 lb.
50 lb. gage back pressure requires a pipe	6.68 / 2.84	or 235 per cent of pipe required for 145 lb.

The utility of high-pressure exhaust steam is evident. In general, wherever the factory use of steam is approximately equal to the power use, low pressure exhaust steam should be used. A factory use of steam of about double the power use or greater will usually justify the highest pressure exhaust steam. Between these limits the economical back pressure will vary as explained above. Because of the many different conditions to be found, further summarization has not yet been thought advisable in this paper, intended only to explain the accompanying charts, as in using them the reader will naturally form his own conclusions.

In so far as this type of chemical plant is concerned, the writer believes the ideal condition of operation is as given in Fig. 26. This assumes that the highest pressure required for the factory processes is 65 lb. absolute, which the writer has found to be true in his plants so far. In those chemical plants where a higher pressure is required, it will be necessary to modify Fig. 26 accordingly.

The steam is generated at a pressure of from 200 to 300 lb., and because of the usual operating conditions the boiler house is a considerable distance from the center of the steam load. Transmission of steam is through a comparatively small pipe, utilizing high velocities. A reduction valve at the receiving end permits rapid and large fluctuations of the steam pressure at the boiler, without affecting the pressure at the engines. These fluctuations may be due to irregularities in firing

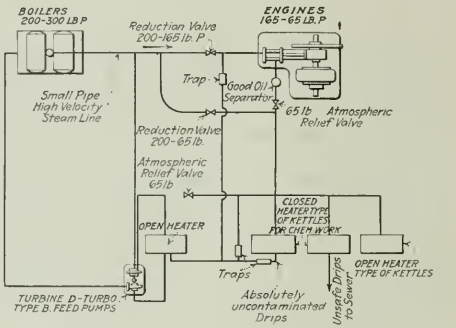


FIG. 26. STEAM LAYOUT FOR CHEMICAL PLANT

and to sudden fluctuations in the demand; the latter are exaggerated because of the smallness of the pipe. This valve, furthermore, tends to dry the steam just before it enters the engines.

The engine exhausts at 65 lb. absolute, and after passing through a good oil separator, the steam is carried to the chemical processes, where it is consumed in one of three principal types of steam consumers. In one, the closed heater type of kettle, the steam is never in contact with the material in the kettle, nor is there any danger to be expected therefrom. Usually this is a heater in which the chemical is never under pressure. The second type is also a closed heater, but as the pressure of the chemical may at some time or other be greater than the pressure of the steam, the drips must be considered unsafe, and either wasted to the sewer or utilized in some other way wherein there is no danger of contaminating the boilers. The third type is the open heater type, in which the steam is actually made a part of the liquid it heats. A closed type boiler feed water heater is also included in both sketch and above description as part of type one, in order to balance any excess steam at 65 lb. Under certain conditions it would be advantageous to use some type three heaters as the supply for boiler feed pumps.

The remainder of the system is evident. It is to be noted, however, that because of the two atmospheric relief valves and two reduction valves, steam pressures must remain practically constant on both the initial and the exhaust steam side of the engines, regardless of the conditions of steam production or of steam consumption.

Influence of Gypsum on the Blast Furnace Slags in the Manufacture of Cement

A Report on the Granulated Slag-Lime-Gypsum Composition Cements as Developed In Russia—Resistance to SO Ion Has Demonstrated Value In Construction Subjected to Sulphate Corrosion

By EUPHIME BERESLAVSKY

ACCORDING to the German patent No. 159,866, "for the preparation of binding materials such as portland cement, damp granulated blast-furnace slags were mixed with unslaked lime and the dry mixture obtained was reduced to powder. However, experiments proved that by applying this method the hydraulic qualities of the grains of slags can be used only superficially. In order to utilize them fully, the mixture of blast-furnace slags and unslaked lime is subjected to the action of elastic steam, after which the mixture is ground. Usually it is necessary, before grinding, to dry the mixture, after subjecting it to the action of elastic steam. In order to avoid this, the granulated slags are first subjected to the action of steam separately and afterward are mixed with the necessary quantity of unslaked lime. Thus a dry mixture is obtained, which is reduced to powder without preliminary drying in mills. The powdered product, which looks like portland cement, is then used in the same way as the latter."

As is evident from this brief synopsis, this German patent is a method of obtaining a binding material, which hardens in water, from the granulated blast-furnace slags and unslaked lime.

The general method of producing binding material (slag cement) is based on the addition of the necessary quantity of hydrated lime to the dried and granulated slags. The addition of lime depends upon the coefficient of the co-relation of the sum of alkali to the acids.

According to the above:

Composition of Slags Used	Per Cent	Composition of Cement Produced	Per Cent
CaO	41.5	CaO	45.4
MgO	3.2	MgO	2.8
SiO_2	42.0	SiO_2	35.7
Fe_2O_3	0.6	Fe_2O_3	0.9
Al_2O_3	10.8	Al_2O_3	9.7
S	1.5	S	1.4
Insoluble residue	0.4	Insoluble residue	0.5
		Loss on ignition	3.6

The tensile strength of this cement:

	Pure Kg. per Sq.Cm.	With Sand (1 Part to 3 Parts), Kg. per Sq.Cm.
After 1 day	9.6	
After 7 days	31.2	10.5
After 28 days	38.2	24.5
After 3 months	....	29.9

Tensile Strength

The tensile strength of the cement is to a certain degree (2.0 to 2.2), according to Tenmayer, proportionate to the coefficient of the co-relation of the sum of alkalis to the acids. This coefficient of the slag, on which I experimented as above, was:

$$\frac{Al_2O_3 + CaO + MgO}{SiO_2} = \frac{9.8 + 42.6 + 1.1}{25.6} = 2.1$$

The slag, preliminarily dried and then ground in the rotary mills, was sifted by me through sieves with 4900 holes per sq.cm.

The average tensile strength (according to Mey) of the normal slag cement should be:

After 7 days	14 to 19 kg. per sq.cm.
After 28 days	20 to 27 kg. per sq.cm.
After 84 days	25 to 30 kg. per sq.cm.
After 210 days	29 to 35 kg. per sq.cm.

Breaking Stress of Normal Slag Cement

The average breaking stress of the normal slag cement (according to Mey):

After 7 days	105 to 133 kg. per sq.cm.
After 28 days	170 to 221 kg. per sq.cm.
After 84 days	220 to 260 kg. per sq.cm.
After 210 days	240 to 288 kg. per sq.cm.

In general, slag cement has less tensile strength than portland cement; however, in admixture with sand it gives reverse results. The setting of slag cement should not be as quick as that of portland cement, and in general the process of hardening should be slower. For instance, the Ashland Pozzolanic cement begins to set within 3 hours and 40 minutes and finally sets within 8 hours.

Matezius' experiments show that the granulated slag changes owing to the influence upon it of elastic steam in a closed vessel, and the mass crumbles and forms a dry powder—a cementitious and hydraulic product.

Although the conditions and nature of work unfortunately did not permit me to test it, yet I presume that if the process of slaking of lime (producing quicklime) is done in a closed vessel in connection with the process of obtaining the dry cementitious powder "matezius" from blast-furnace slags, a strong fusing material (stronger than slag cement) will be obtained if these processes are properly carried out. This, in my opinion, requires special attention.

Lime Does Not Affect Hydraulic Qualities

The quantity of lime added to the slags has no great bearing on the resistance of cement. There may be added 10 to 25 per cent of the entire weight of dry slag. To a good quality of basic slag 10, 15, 20 or 25 per cent of lime may be added without a noticeable change in its hydraulic properties. I believe that the most suitable coefficient for slag cement is about 1.9. Magnesia, of which there is in slag cement sometimes as much as 30 per cent, does not affect the hydraulicity of cement, although there is an opinion that magnesia in combination with gypsum is the cause of inconstancy of volume of cement solutions. The cementitious solution obtained from slags is of a greenish color, which is ex-

plained by the following: The slags contain sulphur in the form of MnS, CaS and $CaSO_4$ (altogether to the amount of 1 to 3 per cent). When granulating:

$$CaS + 2H_2O = Ca(OH)_2 + H_2S$$
$$3H_2S + Fe_2O_3 = 2FeS + 3H_2O + S$$

FeS gives the slag a greenish color. FeS does not affect the properties of cement; samples of it, having a very dark color, did not change in volume after being kept under water for a long time. On the other hand, in the open air it loses all color and becomes white owing to the oxidation of FeS into $FeSO_4$. $CaSO_4$ does not act detrimentally upon the properties of cement, but merely changes the speed of setting.

The tested granulated slag, which gave by itself, without addition of other materials, a breaking stress of less than 4 kg. per sq.cm. after 28 days, upon addition of quicklime (CaO) gave the following results:

90 PER CENT SLAG + 10 PER CENT CaO

Age at Test	Batch Number	Tensile Strength, Kg. per Sq.Cm.	Age at Test	Batch Number	Tensile Strength, Kg. per Sq.Cm.
7 days	1	12.9	28 days	1	36.7
	2	12.7		2	36.2
	3	13.5		3	34.5
	4	14.0		4	38.5

Hydraulic modulus 1.4.
Setting of the slag cement obtained begins after 32 minutes.
Final set within 3 to 4 hours.
Normal consistency of the solution is 31 per cent.

90 PER CENT SLAG + 2 PER CENT RUSSIAN (GLUKHOOZERSK) PORTLAND CEMENT + 10 PER CENT CaO

	Batch Number	Kg. per Sq.Cm.
After 7 days	1	14.5
	2	13.9
	3	13.6
	4	14.0

From this we gather that the admixture of a small quantity of portland cement does not affect the strength of the cement.

BREAKING STRESS

	Batch Number	Kg. per Sq.Cm
Cube with 10 per cent CaO with sand	1	198.6
	2	142.3

TENSILE STRENGTH

One part (90 per cent slag + 10 per cent CaO) to 3 parts standard sand.
Normal consistency of the solution is 9½ per cent water:

	Batch Number	Kg. per Sq.Cm.
After 18 days	1	23.6
	2	23.2
	3	24.1
	4	24.8
	5	20.4
	6	21.4

Storage of briquets—1 days in moist air, 17 days in water.
One part (90 units slag; 2, portland cement; 10, CaO) to 3 parts of standard sand.

	Batch Number	Kg. per Sq.Cm.
After 18 days	1	20.3
	2	18.1
	3	19.2
	4	23.0

As shown above, the strength of the mixture of slag with portland cement is even somewhat smaller than without it.

Mixture of 1 part slag + 25 per cent quicklime, hydraul. modul., 1.93.

THE TENSILE STRENGTH OF BRIQUETS

Normal consistency for 1 part cement and three parts standard sand = 9½ per cent water.

	With Sand — Batch Number	With Sand — Kg. per Sq.Cm.	Without Sand — Batch Number	Without Sand — Kg. per Sq.Cm.
After 28 days	1	150.2	1	284
	2	166.3	2	300
	3	148.7		

One day in moist air, 6 and 27 days in water.

THE BREAKING STRESS (WITH SAND)

Age at Test	Batch Number	Tensile Strength Kg. per Sq.Cm.		Age at Test	Batch Number	Tensile Strength Kg. per Sq.Cm.	
After 7 days	1	13.6	About 200 lb. per Sq.In.	After 28 days	1	28.7	About 400 lb. per Sq.In.
	2	12.0			2	26.7	
	3	12.7			3	26.9	
	4	13.8			4	27.8	

One day in moist air, 6 and 27 days in water.

THE BREAKING STRESS (WITHOUT SAND)

Normal consistency, 34 per cent water.

	Batch Number		
After 7 days	1	27.5 kg. per sq.cm.	About 400 lb. per sq.in.
	2	26.3 kg. per sq.cm.	
	3	28.0 kg. per sq.cm.	

That is, higher than normal, 20 kg. per sq.cm.

	Batch Number		
After 28 days	1	50.2 kg. per sq.cm.	About 650 lb. per sq.in.
	2	47.4 kg. per sq.cm.	
	3	46.2 kg. per sq.cm.	
	4	42.6 kg. per sq.cm.	

That is, higher than normal, 25 kg. per sq.cm.

The cement manufactured by the Russian portland cement works gives:

	Pure	Mixture
After 7 days	About 35 kg. per sq.cm. (About 500 lb. per sq.in.)	About 12 kg. per sq.cm. (170 lb. per sq.in.
After 28 days	About 45 kg. per sq.cm. (About 650 lb. per sq.in.)	About 16 kg. per sq.cm. (225 lb. per sq.in.)

Thus we can see that the cement obtained from the slags, which I tested, of the Alexandrovsk South Russian Works of the Briansk Co., without sand, was approximately equal in strength to the portland cement, and with sand even exceeded it. The cakes made of this cement had proved the constancy of its volume. Consequently, the above granulated basic slag had proved to be a suitable material for the production of slag cement of high quality.

At the beginning of the activity (1913-1914) of the above-mentioned slag works (reorganized) I had an interview with the director and supervisor of the chemical laboratory of the works and during the interview I stated my plans of working with their slags. In the summer of 1914 this plan was tried in the laboratory of these works, and later on in the shops, and gave good results. In 1917, when I visited the works, they were at the height of their productivity. Wishing to make a further study of the properties of slag and of its interaction with lime and gypsum, I applied the mathematical rule of combination of these elements.

Combinations That Are Possible

The following combinations are possible:

Elements:

1. Granulated slag.
2. Non-granulated, or, more correctly, degranulated slag.
3. Lime (quicklime).
4. Gypsum (burnt and semi-hydrous).

Possible combinations of the four elements, in twos (C_4^2):

1 and 2	2 and 3	3 and 4
1 and 3	2 and 4	.....
1 and 4	.....	.....

Combinations of the four, in threes (C_4^3):

1	2	3	2	3	4
1	3	4	2	1	4

There can be no other combinations.

Five Useful Combinations

Excepting the combinations that are useless for us, 1 and 2, 2 and 3, 3 and 4, 1, 2 and 3 and 1, 2 and 4, we have five combinations, which will serve me for my investigations. If we set aside the combination of granulated slag with lime (1 and 3), already tested, only two binary mixtures remain:

(a) Granulated slag with gypsum.

(b) Degranulated slag with gypsum.

Two ternary mixtures remain:

(a) Granulated slag with lime and gypsum.

(b) Degranulated slag with lime and gypsum.

By "degranulated" I mean the granulated slag, which I had, and in which all granulation properties had been eliminated by means of preliminary heating up to a high temperature and subsequent slow cooling in a closed kiln.

In the fusion of slag and gypsum there can finally take place such a co-relation of the component parts of the combination that it would resemble the so-called "cement bacillus," to which Candlot and Deval have given the formula Al_2O_3, 3CaO, $3CaSO_4$, 28.4 H_2O. This fusion after the hardening of the cement solution produces a large increase of volume. A small quantity of burnt gypsum, on the other hand, acts beneficially. Without altering the volume it retards the setting of the cement and increases its strength.

Finding Most Favorable "State of Balance"

The retardation of the setting is explained by the fact that burnt gypsum does not enter into interaction with $CaOH_2$. The formation of "cement bacillus" destroys this retarding influence in the setting. The finding of the most favorable "state of balance" of the component parts of the mixture of slag and gypsum is the fundamental problem of our theme. The answer can be given only approximately and as applied to the slag used in the test.

There are indications that by partial addition of gypsum to granulated slag it was possible to obtain a tensile strength of 43 kg. per sq.cm. after 28 days, but the amount of the addition and the co-relation of the gypsum elements to the others I have not been able to determine. From my investigations I would say that the addition of 10 to 15 per cent of gypsum is the most suitable, although I was not successful in obtaining thereby a very high strength in the cement.

Adding from 1 to 25 per cent to our slag we gradually approach Deval's formula, but to reach this formula absolutely, without the introduction of alumina, is impossible, as can be seen from the chemical analysis of the slag tested. By adding 25 per cent of gypsum the following compound is obtained:

Al_2O_3	CaO	$CaSO_4$
1	3	4

Combinations with this amount of $CaSO_4$ (25 per cent) and a little more (30 per cent to 35 per cent) produce negative results.

Thus cubes made of a combination of degranulated slag with 25 per cent of gypsum gave after 28 days a breaking stress of only 63 kg. per sq.cm. and tensile strength of 7.4 kg. per sq.cm. Eight-shapes of the same mixture, but with sand, gave a breaking stress after 28 days of 4 kg. per sq.cm., a slag being used in which granulation had been eliminated by means of preliminary heating up to a temperature of 1280 to 1300 deg. (No. 9 = 10 Zeger pyramid) in a gas kiln and subsequent slow cooling in a closed kiln.

Some of the briquets composed of (1) granulated slag with 5 per cent of gypsum, (2) degranulated slag with 5 per cent of gypsum, placed in water became quite soft after two days, and part disintegrated and turned almost into mud. Those of the briquets that, after remaining two days in a moist place (above water), had not been put in water, but were left for several days in the open air and then for experiment put in water, disintegrated entirely within a few hours.

Samples made of 85 parts of granulated slags to 10 parts of quicklime to 5 parts of $CaSO_4$ and 85 parts of degranulated slags to 10 parts of quicklime to 5 parts of $CaSO_4$ had swelled, cracked and changed their volumes (just as slags of same composition but with sand) after being in water for 7 days.

Effect of Adding Gypsum

Consequently, slag cement (even with an enlarged hydro-modulus) made of granulated slag and 10 per cent of quicklime, which had, as shown above, a good stress, lost its stress on addition of 5 per cent of burnt (and semi-hydrous) gypsum and also changed its volume.

When I repeated the experiments, keeping to the addition of 4 to 6 per cent of well-burnt gypsum continuously to the granulated slag and slag wherein granulation had been eliminated, the results were the same. After two days the briquets with sand, which had been lying in water, disintegrated entirely, part of briquets (without sand) changed in volume, having swelled and formed large cracks, while the slightest contact broke them up. The final hardening of the samples was sometimes not noticeable even after two days, and a touch of the finger left a mark. Other samples broke up by themselves, not having hardened completely.

With the increase of the amount of gypsum added up to 10 to 12 per cent of the total weight of the mass, the fusing properties of the hydraulic mixture began to appear thus:

90 parts of degranulated slag to 10 per cent $CaSO_4$ (burned) gave the following average:

	Batch		
After 7 days.....	1	10.2 kg. per sq.cm.	Or about 150 lb. per sq.in.
	2	10.7 kg. per sq.cm.	
	3	10.3 kg. per sq.cm.	
	Batch		
After 28 days.....	1	23.7 kg. per sq.cm.	Or about 350 lb. per sq.in.
	2	24.2 kg. per sq.cm.	
	3	22.4 kg. per sq.cm.	

When 15 per cent of $CaSO_4$ was added to the total weight of the mixture the resistances were about the same. After further additions, however, the resistances in my experiments began to fall. No change of volume was noticeable. Parts of matte cement remained firm and hard and showed no signs of distortion, cracking, checking or disintegration in the steam test for soundness. The beginning and final setting I tested with the Vicat apparatus. Setting commenced on the average after 15 to 25 minutes and final setting took place after a few hours.

How Lime and Gypsum Influence the Constancy of Volume and the Setting of Cement

We shall now consider lime and gypsum as factors influencing the constancy of volume and the setting of cement.

According to Dr. Kuhl's report before the Society of German Manufacturers of Portland Cement in 1912,[1] the increase of volume $Ca(OH)_2$ during the hydration of the component parts of the cement clinker produces inconstancy of the fusing material. This, however, does

[1]Russian Journal "Cement," Vol. I, 1914.

not always happen. Kuhl's supposition was that the hardened cement has a certain space for the formation of $Ca(OH)_2$; that is, certain processes take place in connection with the reduction of volume, thereby creating the necessary space for the appearing hydrate of lime. In hardening, one part of the lime changes into hydrate, while the other part forms hydraulic silicates and aluminate. These processes act as if in completion of one another and in certain co-relations no change of volume takes place. The resistances within the paste are then equalized by counter forces outside. As is known inconstancy of volume is also the result of a too great content of gypsum. This is considered by Kuhl in the same light as the above in connection with the decrease or increase of volume during the hardening of the cement. The hydrate of the lime in this instance is substituted by sulpho-aluminate lime (according to Le Chatelier Al_2O_3, 3CaO, $3CaSO_4$, 28.4 H_2O), or as Michaelis calls it, "cement bacillus," formed of gypsum and hydraulic aluminate of lime.

As I have remarked, the inconstancy of volume is caused by the content of too much gypsum; it does not follow, however, that gypsum is always harmful, as it changes the volume in hardening. On the contrary, where there is not a sufficient amount of hydrate of lime to obtain high strength and not all the free space in the thick of the lime is filled by it, the presence of "cement bacillus" is indeed very useful, as it fills up the space remaining empty.

Therefore, reviewing the inconstancy of volume of cement in connection with gypsum, we must consider it as depending not only upon the amount of gypsum itself, but also in a great measure upon the amount of lime in the cement.

Placing the content of gypsum in the cement in connection with the amount of lime, Dr. Kuhl cited a number of examples proving that as a matter of fact with a low hydro-modulus of portland cements, as for instance, with a hydro-modulus of 1.85, 6 per cent of $CaSO_4$ is required, while with a hydro-modulus of 2.3 only 0 to 1½ per cent is necessary for best strength with no modification of volume.

It is now considered as proved that inconstancy of volume from gypsum depends not on the absolute amount of lime, but upon the relation of gypsum to lime, and that this is especially observed in cements obtained from blast-furnace slags. According to Kuhl, blast-furnace slag granulated in water, with an addition of 3 per cent of gypsum, after 28 days (hardening under water in mixture with sand 1 part to 3 parts) had a tensile strength of 6 kg. per sq.cm. and breaking stress 38 kg. per sq.cm. Owing to the increased addition of gypsum, the 28 days strength of the hydrated samples grew progressively for tensile strength, 27 and 40 and 43 kg. per sq.cm., and for breaking stress, 196 and 412 and finally 604 kg. per sq.cm.

As has been remarked by Kuhl (this has been corroborated by builders in the south of Russia in port construction in the Azov and Black Seas), the relation of cements with poor content of lime to gypsum makes them especially suitable for marine construction; as the cement is the less sensitive to the acid substances of sea water the more gypsum the cement can take in without disturbing the constancy of volume. The more lime is substituted by gypsum, the more suitable will the cement be for marine construction.

Cements that require considerable amounts of gypsum (10 per cent and more) in order to evidence good properties become immune from the destructive action of sulphuric acids; they are inoculated, so to speak. The corresponding action of the gypsum that forms subsequently will be the weaker according as more gypsum is contained in the cement originally.

Conclusion

Cement prepared with a corresponding co-relation of gypsum and slag and properly prepared can be used in the construction of quays, cisterns, reservoirs, canals, bridge supports, etc. When used for molding stones and artificial marble, which may break by rapid drying, they should at first be moistened.

In conclusion I wish to mention the following additional points:

1. Various cements obtained from blast-furnace slags, when they are the most important component parts (in per cent) of the raw material obtained, cannot and shall not be accepted on the general rules applied to ordinary portland cement. For the acceptance of above mentioned cements the content of sulphuric anhydrate (SO_3) in them must be found in a quantity of more than 2 per cent and even in higher quantities in order to secure their physical and mechanical properties and their resistances, as demanded by the standard regulations for portland cement.

2. A change of this sort makes it possible to utilize properly, without endangering the strength of the buildings, those rather large quantities of slags which have accumulated during the war at the metallurgical works and which cannot be worked into cement in any other way.

Although such cement would not answer in its chemical composition to the standard international specifications, a very fine and cheap cement could be obtained from these slags if the manufacture of it is properly organized.

The Present Status of Oil Shales

MUCH publicity of various sorts has recently been accorded the huge deposits of oil shales occuring in the Uintah Basin, occupying the northeastern portion of Utah south of the Uintah Mountains and extending eastward into Colorado. A less-known region of western Wyoming occupying the Green River Basin northward from the Uintah Mountains to the Wind River Mountains probably contains an even greater area of oil shale beds. A third deposit of enormous size lies astride the Colorado-Wyoming border sixty miles further east.

In addition to these tremendous and only roughly-mapped regions, an area of about 2500 square miles of good oil shale has been located in the central part of Utah, near Manti. Near the station of Elko, Nevada, on the Western Pacific Railroad, occurs a relatively small area upon which many locations have been made. In fact patches of oil shales up to 100 square miles in extent may be found at numerous spots all over the Rocky Mountain region. These are in addition to the numerous small areas of asphaltic sandstones (popu-

larly known as "oil sands") scattered through the Western plateau, in area up to a few townships. Of the latter, a well known and large irregular deposit occurs in the San Raphael swell 60 miles south of Price, Utah, and another near White Rock in northeastern Utah.

Superficial Appearance

The shales themselves vary greatly in superficial appearance as well as in physical properties. Thus, the color, specific gravity and yield change in perfectly discontinuous fashion, so that about the only generalization one may make is that eye-examination tells nothing as to the possibilities of the sample. Broadly speaking, it may also be said that differences in appearance are

FIG. 1. HELL'S HOLE CANYON, NEAR WHITE RIVER, UTAH

regional rather than stratigraphical; the layers in a bed at a certain locality frequently look much alike, but may vary greatly in oil content. As is only natural from the wide distribution and immensity of the deposits, the amount of lean overburden above the workable seams is also subject to large variation. Usually oil-shale beds will be exposed on the high, steep-sided bluffs cut by river erosion, as is shown in Fig. 1, while the back country shows few outcrops; in general the rolling surface consists of more or less disintegrated rock, quite often of shale which has lost but little of its original carbonaceous matter by atmospheric oxidation. Sometimes rivers have carved valleys hundreds of feet deep through kerogen-bearing strata without reaching barren material. It is also fortunate that the areas were not folded to any great extent in their upheaval from the ocean bed, nor are they buried to any depth under other sediments of more recent date. In this as well as many other characteristics our Western shales are so different from those treated by the oft-quoted Scottish industry that analogies cannot be drawn safely.

Nature of Kerogens

The geological origin of the shales is a matter of considerable interest, but as yet the problem has not been definitely solved. Since there seems to be a complete and unbroken series from lean oil shales to lignites, information on such coals should be illuminating. According to Potonié and Heinold, non-bituminous lignite coals were formed at regions where extensive subtropical flora grew in swamps and where the remains of this vegetation accumulated into a peat bog. Sand or clay then collected during a subsidence of the ground, and this impervious covering protected the carbonaceous deposit from entirely rotting away. The bituminous lignites were formed in the same regions during droughts, when the cellulose exposed to the air decomposed to water and carbon dioxide, while the fats and wax resins remained intact. Bituminous shales were formed largely of these unoxidized organic remains swept down by rivers into a deep, quiescent lake or arm of the sea. Many traces of animal life have also been identified in oil shales; Western shales also contain more or less carbonate, probably organic in origin. Thus, these complex hydrocarbons, the remains of animal and vegetable life, were deposited during the building of the sedimentary beds by the accumulation of the smallest particles of inorganic sediment—largely calcium, magnesium and aluminium silicates. During the long stretch of time the beds became of tremendous thickness, and eventually, by a change in the geological conditions, were overlain by other sediments carrying no carbonaceous matter, and pressure-metamorphosed into shale beds (Fig. 2).

One great distinction holds between the oil-forming materials of shale and bituminous lignites, however, which is not explained by the preceding theory. This is that the bitumen in lignite is soluble in many common organic liquids, such as benzol, alcohol and carbon disulphide, while the carbonaceous materials of Messel coal and oil shales (particularly Scottish shales) are not soluble to any great extent. The definition of the term "bitumen" has consequently been stretched to cover all substances which furnish oils and tar when subjected to dry distillation. Brown's suggestion is better: Call the organic remains in shales "kerogens," since they are substances capable of producing oils, and yet are apparently neither bitumen, petroleum nor resin.

Foreign vs. American Processes

Bituminous lignites and shales have been retorted in Germany, Scotland and France for many years. Each material produces a variety of gaseous and oily fractions, together with solid paraffines and coke. Even with the

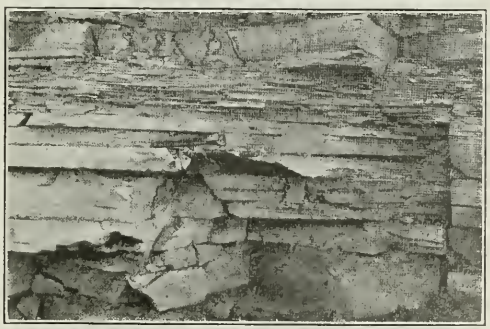


FIG. 2. CLOSE VIEW OF AN OIL SHALE FORMATION
(Courtesy of the D. & R. G. Ry.)

low price of foreign labor, the sale of the coke resulting from lignite-retorting is the return which keeps these enterprises alive; while the Scottish shale industry exists by virtue of the ammonia recovered as a "by-product." In the development of these foreign processes almost every conceivable type of retort was "invented," and many of them tried in practice. The early investi-

gators soon found themselves on the horns of a dilemma —intermittent retorts successfully produced gas, oil and coke, but were of very low capacity. On the other hand continuous retorts gave bigger tonnage but an incomplete recovery, and the oils produced were of low quality. Many trials resulted in the survival of gas-heated vertical retorts lined with iron and brick, with a slowly descending charge column. By means of heating flues built in the sidewalls of the shafts, the temperature is closely controlled; indeed, such regulation is absolutely essential for the production of satisfactory volatiles and residues.

Apparently the first thing which an American does when he discovers the existence of oil shale is to invent a process or furnace for getting the oil. Scores of patents have been issued, but it is doubtful if many of them are commercially plausible, and questionable whether the best of these present any improvement or addition to previous knowledge which will withstand a legal attack. In the attempt to reduce the modest amount of labor required by the successful Scottish retorts, many mechanical monstrosities have been evolved whose operation would require a gang of mechanics and a heap of repair parts. Others exhibit the utmost ignorance not alone of distillation methods, but of furnace design and the principles of combustion and chemistry. It would seem that some company organized primarily to get shale oil would be well advised to erect Scottish retorts and adapt them to local conditions. These well-tried furnaces are mechanically good —they operate on recovered gas with a minimum of labor, make a good yield of satisfactory crude oil with an increasing amount of paraffine, and permit the recovery of large amounts of ammonium sulphate. Should labor-saving devices be considered essential, the modern by-product coke oven with its marvellous mechanical equipment could be taken as a model, and so modified as to produce the regular temperature cycle needed for maximum yield.

As a matter of fact, on Dec. 1, 1918, of all the proposed processes and organized companies, not one was producing crude oil. In addition to this fact, there are but two or three plants ready to operate on a commercial scale—that is to say, for more than small-scale experimentation. One may understand how much of the shale agitation is merely words when it is doubtful if more than twenty barrels of crude have been produced to date from Western shale!

Construction at Elko and Watson

Perhaps the most promising attempt now under way is that financed by the Southern Pacific railroad at Elko, Nevada, where this company is erecting a Henderson retort (Scottish) for distilling shale. The Bureau of Mines is co-operating with this effort and has detailed David T. Day to act as consulting chemist. With adequate financial support and technical supervision, this attempt to adapt successful foreign practice to a local deposit should produce a mass of invaluable information.

In the Uintah basin, at Watson, Utah, the end of a 60-mile narrow-gage railroad running northwest from Mack, Colorado, the Ute Oil Co. is planning to install a 400-ton plant on the so-called "Wallace process." The bulk of the material for this plant is now on the ground, but actual construction has not yet started. The Wallace process is discontinuous and uses a vertical retort, heated from the outside. Vaporized hydrocarbons are to be withdrawn through a perforated tube extending axially down the retort. It is stated that the heating period is to be 55 minutes, which is approximately 5 per cent of the time used in passing the charge through the Scottish furnaces. It is also doubtful whether the mechanical contrivances proposed for charging and discharging will sufficiently counteract the inherent disadvantages of intermittent operation.

Activity at DeBeque

DeBeque, in western Colorado on the Denver and Rio Grande Railway, may be regarded as the center of the oil shale boom. At or near here are the sites of three plants, at each of which some work has been done. The American Shale Refinery Co. is putting up a so-called "Wingett retort," which is somewhat similar to a tall Wedge roaster. It is understood that the shale will be crushed to 10 mesh, and that the rabble arms will travel at about 30 rotations per minute! The inventor thinks he can charge 100 tons of shale per day, but as yet has no information as to whether the retort will deliver crude oil, or merely dust.

DeBeque is the scene of operations of the Mt. Logan Oil Co., which has three 20-ton units of the Galloupe process on the ground, but not yet installed. This is a long, inclined retort of crescent cross section so set that the heating gases play upon the cylindrical bottom, and contains a stirring arm manually oscillated. Volatiles are removed from the outer edges.

Two small modified Henderson retorts were erected near DeBeque about a year ago by the Oil Shale Mining Co. One of these was operated for a short while at the time of completion, and the other given short trials recently, but not much oil was made in either attempt. This company has six 6-ton units on the ground, but is not producing any oil at the present time.

Products of Distillation

Thus it appears that little of the energy so far devoted to this subject has carried the enthusiasts to the producing stage. Indeed, little is known of the substances which will be produced upon retorting. Evidently the assumption has been generally made that the products will be somewhat analogous to those of the Scottish industry. Here sufficient permanent gas is evolved to operate the process, and the crude oil is successfully fractionated and marketed as naphtha, lamp oil, gas oil, lubricating oils and paraffines by processes very similar to those in use in petroleum refineries. On the other hand, what little work has been published on Western shales show that the products of retorting are quite different from the ordinary oils of commerce. Thus, Morrell and Egloff in Chemical & Metallurgical Engineering, Vol. 19, p. 90, (July 15, 1918), and Dr. W. D. Bonner, working independently at the University of Utah, have all shown that the oils are full of highly unsaturated compounds, that they contain considerable nitrogen and sulphur and that the ordinary method of fractionating followed by acid-soda treatment does not produce stable oils of correct color, odor, specific gravity and volatility to be readily absorbed by the American market except at the expense of prohibi-

tive treatment losses. Predictions that the oil shales would produce billions of barrels of gasoline are not founded on correct premises, for the percentage of low-volatile compounds are less than assumed, and this fraction is not a distillate suitable for internal-combustion engines, since it contains its share of the complex compounds contained in the crude. Even the amount of recoverable nitrogen is so small as to reduce seriously the income from this source. Thus, the shale banks so far tested contain on the average not more than 0.6 to 0.7 per cent nitrogen. Suppose half of this is recoverable as ammonium sulphate, which would be most excellent practice from a retorter's standpoint, the shale would yield 25 or 30 pounds per ton under most favorable conditions—markedly less than that of Scottish practice. As a matter of fact the best ammonia recovery had in Dr. Bonner's work amounted to but 10 per cent of the nitrogen contents.

These statements should not be interpreted as meaning that our immense deposits of oil shale cannot be counted upon eventually to supplement the petroleum production. It cannot be too strongly urged, however, that the successful exploitation of these reserves will require the most painstaking and persistent research on the part of a competent technical and selling staff—either a retorting process must be discovered which will produce good yields of normal crude, or easy methods perfected to separate the unstable compounds, uses discovered for them, and the market educated to absorb them. Evidently this development is impossible as long as the promotor remains the prominent feature of the situation!

Treatment of Asphaltic Sandstone

A sharp distinction should be drawn between the preceding discussion of oil shales and the following information on asphaltic sandstones. As already stated, these so-called "oil sands" occur in thick and extensive deposits at many scattered localities throughout the Rocky Mountains. They consist of beds of fine, rounded sand, cemented with a heavy asphaltic oil; their nature suggests that they represent the remains of a petroleum deposit which has been so exposed that the lighter oils have evaporated, leaving the heavier residue behind.

That the kerogen in asphaltic sandstone is essentially different from that in oil shale is evidenced by the fact that it can be easily leached from the sandy aggregate by gasoline and other organic solvents. This has been done in a continuous manner at the University of Utah. A traveling belt operating in a closed leaching tank elevated the sandy residue above the surface of the digesting liquid, there to be sprayed first with solvent decanted from the sump, and later by clear gasoline recovered from the stripping still and discharge trap. The well known system of continuous counter-current decantation perfected for cyaniding and applied to numerous chemical and metallurgical leaching processes comes to mind as being quite applicable for this extraction. Covered agitators and thickeners would be used—in fact the whole system would be gas-tight in order to prevent the volatilization of the solvent, while the final sludge would pass through a filter and drier to recover the last of the gasoline or other leaching medium. The rich solutions thus formed may be separated from the solvent in a stripping still. The liquid residue is a heavy viscous oil, which is about 10 deg. Baume gravity yielding little material under 200 deg. C. when distilled. As far as studied, it appears to be quite similar to the heavy parts of Mexican and Californian petroleum, and will yield gasoline by cracking, lubricating oils, road tars and coke of marketable quality and by ordinary refining methods.

Large scale experimentation on distilling this asphaltic sandstone is to be undertaken at Casmalia, California, a point on the Southern Pacific railroad near Santa Maria, where a so-called "Day-Reed" plant is being built. The furnace consists of three tubular retorts, egg-shaped in cross section, set one above another between headers, and the whole mounted in a rectangular furnace. The retorts themselves are about 20 feet long by 15 inches high. The broken standstone enters one end of the top retort and is worked slowly to the other end by a screw conveyor; it falls through the header into the second retort, and is worked back and forth through the remaining retorts in a similar manner. Suitable exits for gas, light and heavy oils are provided.

Power at Pittsburgh

AT THE last local meeting of the American Electrochemical Society at Pittsburgh, the program was opened by a fine paper from Dr. J. F. Schrader of the Westinghouse Research Laboratory, who described the latest devices for the "Production and Measurement of High Vacua." The paper was illustrated by slides.

This was followed by an informal symposium on the electric and electrochemical interests of the Pittsburgh region. In the course of this some interesting notes by Carl G. Schluederberg, the well known "live wire" of the Westinghouse Electric & Manufacturing Co., brought out the fact that the Niagara power costs may possibly be reached in the Pittsburgh region before long. It used to be said that there would never be any such power supply at Pittsburgh to equal, say, 500,000 hp. But the statement was made that some large interests are planning now for huge plants, both coal at the mine and water power, which will give a total of nearly 700,000 kilowatts. The statement was also made that the cost of this power would, when normal conditions arrive, presumably be as low as that of power anywhere in this country.

This symposium was only the prelude to an interesting series of papers of the general electric outlook in the Pittsburgh region which it is planned to bring out before the Pittsburgh Section this winter. Interest in the local Section and its work is growing, through the energetic work of the chairman for the last year, Mr. R. E. Zimmerman of the Research Laboratory of the American Sheet & Tin Plate Co. at Pittsburgh.

Pro Patria, Pro Meter, Pro Liter

In the announcement put forth by the American Metric Association a new slogan has been adopted which reads "Pro Patria, pro meter, pro liter!" We favor the idea. At the same time we wonder whether the phrase is entirely happy. In most of us our school-boy Latin has so degenerated that we are apt to read a false meaning into the simplest expressions in the language. For instance the new slogan may unhappily be translated, "For Father, for Mother, and for a Long Drink."

Mercury Production at Almaden, Spain

Statement of Marketing Conditions—Contract with Rothschild of London and the Method by Which the Price Is Controlled—Ore Sorting and Sampling—Bustamente and Cermak Furnaces—Condensers—Production and Costs

By Dr. ROLAND STERNER-RAINER[1]

COMPARISON of production statistics, shown in Fig. 1, the world over shows that Europe has regained the lead since the peak of California's production, which occurred in the '70s of the last century. It also seems that Europe will increase its lead. Three European states at present produce a considerable part of the world's output. In the past year Spain led the production with 1500 metric tons;[2] then follows Italy with nearly 1000 metric tons, and then Austria-Hungary with nearly 850 metric tons. Besides the three largest quicksilver mines in the world—Almaden, Monte Amiata and Idria, which give the above-mentioned countries the lead in production—there are in Europe a number of smaller mines which produce notable amounts of quicksilver, either directly or as a by-product. Since, in general, there is little of interest in the method of ore dressing and reduction employed by these small plants, this section will concern itself mainly with the first of the large plants mentioned.

Environs of Almaden

The mining town of Almaden lies in the Spanish province of New Castle, near the boundary of Estremadura, and is somewhat off the road of travel—as most mining towns are. The railroad connecting Madrid with Portugal, via the Spanish border town of Bajodoz, passes through the village of Almadenejos, in the province of Ciudad-Real. The railroad station is called Chillon, and from here the city is reached over a stony road about 10 km. long. Almaden lies on the north slope of the Sierra Morena, in the highlands of central Castile, about 700 m. above sea level; the surrounding country is unproductive pasture land crossed by rocky escarpments. The whitewashed, one-story houses of the 8000 inhabitants lie mostly along one long, cobblestone road which runs along the ridge of a low hill which rises toward the west and reaches its highest elevation at the end of the city, where an old Moorish fort rests upon the crown of the hill. Most of the shafts are found a little farther on, and at the foot of the hill is the metallurgical plant, which is connected with the mines by an incline, the so-called "Plano-Automotor."

Of the earliest history of the plant no more is known than is recorded in the book of the engineer Cyarzabal, of which only one copy exists, in possession of the management. Little has been published about the ore occurrence, mining methods, metallurgy and production other than that found in various text books.

The ore bodies of Almaden, which extend under the city, are found only in the Silurian, which consists of clay slates, interbedded limestones and quartzites, which latter pass into micaceous sandstones. Three of these quartzites, having an average thickness of 8 to 14 meters, are impregnated with cinnabar. They merge gradually into the barren quartzites, but have a sharp contact with the slates. These ore bodies have become richer in depth, whereas several others in the neighborhood, as at Almadenejos and in the Val de Azogues, where La Concepcion is the oldest of the now abandoned quicksilver mines of the district, became impoverished in depth. Besides cinnabar, small quantities of "azogue virgin," or metallic quicksilver, are found. Pyrite is also present, as are traces of selenium and arsenic. Gangue minerals are almost entirely absent and are confined to a little heavy spar, dolomite and small vugs of bituminous matter.

The main ore body has an average assay value of 14 to 15 per cent mercury, while the two northerly ore bodies, which are not as large, carry lower-grade ore in part, the content of which may be as low as 2.5 per cent mercury. The average content of the ore treated during the last years has remained fairly constant and equals 11 per cent mercury;[3] the width of the ore zones is greater, if anything, than in past years. The production, however, has not been increased, even though the ore at present developed assures a forty-year life of the property with an annual production of 1000 metric tons of quicksilver. With this reserve the production could, of course, be increased to any desired figure.

Method of Controlling Price

The production has not been increased, because overproduction might so lower the price that the advantages of increased production would be nullified. Even though the Spanish Government is bound by contract to sell the entire quicksilver production through the House of Rothschild in London, enabling the latter to regulate the price by controlling the amount of quicksilver placed on the market, other quicksilver-producing countries, due to their production, are powerful enough to prevent a quicksilver monopoly on the part of Rothschild.

The contract of the Spanish Government, the sole

[1] A portion of an article published in "Osterreichische Zeitschrift für Berg- und Hüttenwesen, Vol. 62, 1914, p. 529. Translated by C. N. Schuette in connection with a coöperative investigation of the metallurgy of mercury being carried on by the United States Bureau of Mines, and the New Idria Quicksilver Mining Co., and published by their courtesy.

[2] 1 metric ton = 1000 kg. = 2204.6 lb.

[3] (Translator's note.) The quantity of ore treated, presumably in the year 1912, is given later as 16,600 metric tons. The quicksilver production for this period is 35,400 flasks, corresponding to 2.13 flasks (34.5 kg.) per ton, or a yield of 7.35 per cent of the weight of the ore treated. The discrepancy between this and the average content of the ore as here stated is probably due partly to loss in treatment, which is known to be large, and partly to errors in sampling. It is generally believed by quicksilver operators that samples, as usually taken, give results indicating a higher grade of ore than actually occurs.

owner of the mines, with Rothschild was closed as a result of a public competitive submission of proposals. The contract dates from Jan. 1, 1912, and is effective for ten years. Of the total amount of quicksilver produced by the mines of Almaden, 500 flasks are reserved to the national industries of Spain. All else is included in the contract. The contractor binds himself to sell, in London, the greatest possible quantity of mercury, which he takes over f.o.b. reduction plant at a price of more than seven pounds (libres) per flask. In return for the observance of this obligation, he receives: 1. A commission of 1.25 per cent of the net value of the sales. 2. Six shillings (chelines) for each flask that he transports to London. 3. Ten per cent of the sales price above £8:2 on any sales made above this figure.

Ore Sorting and Sampling

In order to prepare the run-of-mine ore for future treatment (a "preparacion mecanica," or ore-dressing plant, has been planned but not erected) it is transported to a large sorting floor in ox-carts; here the ore is roughly sorted by hand. High-grade ore, distinguishable by its bright color, is put aside, as is the lower-grade ore and the very low-grade wall-rock. Barren rock, bricks and wood refuse is picked out. From the remainder of the ore the larger pieces are separated with iron rakes. This ore is then screened on screens having a 5-cm. opening, thus separating the coarse and fine. After the largest pieces of the two classes of higher-grade ore and a part of the very low-grade ore have been hand-cobbed to fist size, the following grades may be distinguished:

Class I. "Metal," contains about 22 per cent Hg
Class II. "China," contains about 9 per cent Hg
Class III. "Solera," contains about 3 per cent Hg

and finally the fine ore, a mixture of the comminuted material of all classes called "vasisco," with a content of about 5 to 7 per cent mercury. During the last year 16,600 metric tons of ore were treated at the plant, of which about 13 per cent was classed as "metal," 38 per cent as "china," 34 per cent as "solera" and 15 per cent as "vasisco."

The ore is sampled in the carts and cars which transport it to the furnaces. The assay sample is mixed with hammerscales and red lead in a porcelain crucible having a gold-leaf cover and heated for three minutes. The sampling and assaying are very carelessly done. Complete analyses of the ore are not available, as the assay office is not equipped for exact work and lacks a competent analyst.

Operation of Bustamente Furnaces

By far the greater part of the ore is treated in eleven twin furnaces, "hornos Bustamente" or "hornos de aludeles" (Fig. 2). Since all of the larger metallurgical plants have long since replaced this wasteful apparatus with modern installations, Almaden is one of the few localities in Europe where this historic furnace (invented by the Peruvian Dr. Don Lopez Saaverda-Barba in 1633 at Huancavelica and introduced into Almaden by Don Alfonso Bustamente in 1646) is extensively operated. The furnace erected at that time (1646) is still in operation, while the last one was erected in 1882. Construction of this shaft furnace is too well known from the text books[1] to warrant comment here.

When the furnace operation is to be resumed it becomes necessary to draw the still warm furnace tailings, which carry about 0.012 per cent. The furnace tails are carried to the dump, which in the course of time has become tremendous, in saddle baskets on mule back. First, the larger pieces of "solera" are introduced into the shaft, the object being to prevent fine ore from falling through the convex brick grate. On this is placed "china," then "metal" and finally briquets of soot and "vasisco." On top of the ore several pans of fresh soot are placed supported by a sheet metal frame. The lump ore is charged through the side doors as far as possible, the rest being dropped through the top charge door. When both openings are closed the furnace is fired, and the ores burned for two days. After the fire has been drawn, the side and charge doors are opened to allow the cold air to enter the furnace shaft and cool the tailings.

Then the "levante," or clean-up, is started. The connections between the ascending and descending condenser branches are severed and the "aludels," also called "canos," which lead from the furnace, are taken out and placed on the aludel floor, where the quicksilver flows out and the greater part of the soot is collected.

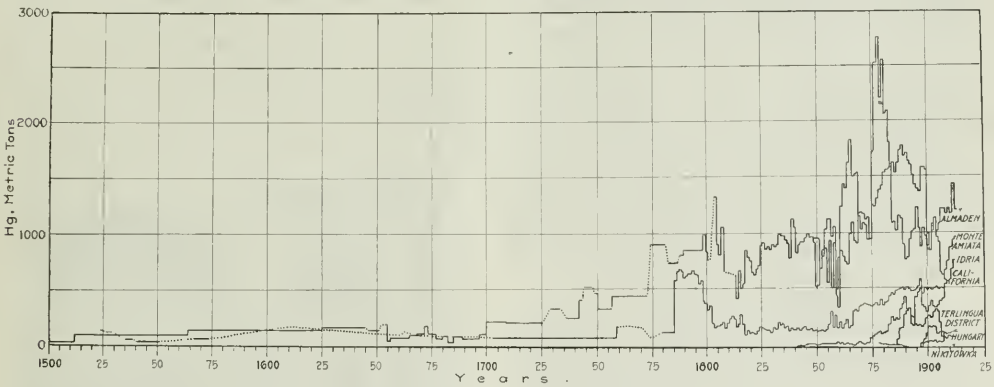


FIG. 1. WORLD'S PRODUCTION OF MERCURY FROM 1500 TO 1912

[1] Schnabel, C., Handbook of Metallurgy, Vol. 2, p. 348.

The emptied aludels, which resemble porous clay pots without a bottom, are set on the clean floor, the latter being swept from the furnaces down to the central gutter when the aludels are replaced immediately. Broken aludels are replaced by new ones of local manufacture which cost 30 centimos, and the old ones are burned in the next furnace charge. The joints between aludels are luted with a ferruginous red clay found in the neighborhood, and the furnace is ready for the next charge. The free quicksilver runs off through a floor drain into a pot below, from which an iron pipe con-

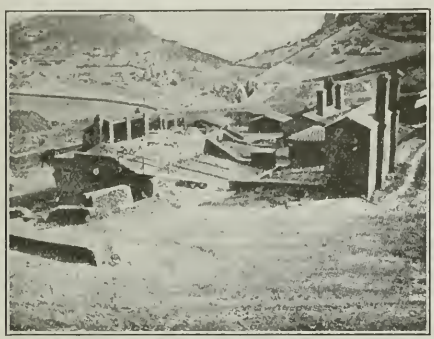


FIG. 2. BUSTAMENTE FURNACE AT ALMADEN

ducts it to the storehouse. The high-grade soot is hoed with perforated hoes until most of the trapped quicksilver has been extracted, and then is carried in woven hand baskets, called "espuertas" or "capassos," to a room at the side of the condensation chamber, where it is further treated. A considerable amount of quicksilver is scattered by all this handling. One finds puddles of mercury on all these furnaces and in their vicinity, to say nothing of the fact that the masonry and the ground are impregnated with visible droplets.

Estimation of Losses

No determinations of losses have been made, and not even estimates of probable losses are at hand. The sampling as practiced does not give reliable information as to the furnace input. It may be taken for granted that the diffusion of mercury fumes is enormous, considering the large surface presented by the lines of aludels. A considerable volume of the furnace gas escapes through the small hole in the bottom of each aludel, which is designed to afford a means of escape for the condensed quicksilver. The luting of the aludels is not so perfect as to prevent a light blue haze from hanging over them. Many of the aludels are covered with droplets of mercury on the outside, a sign that the metal was condensed when escaping. Further condensation in the fume chamber, which is divided only into two parts, is not capable of completely separating all the mercury which passes the aludel strings. The operation of the plant is discontinued during the first days of May, to be resumed during the cool days of autumn, as the hot sun practically prevents the condensation of mercury in the aludels. At that, the losses during the winter months must be very high, which is significant when the high grade of the ore and the amount of mercury produced is considered. Officially, losses are given as 3 per cent, which would amount to 36,000 kg. of mercury semi-annually, but considering all factors, it would probably be more nearly correct to place the loss at four or five times that figure.

The charge of a twin furnace consisted of 5400 kg. "metal," 9960 kg. "china," 2800 kg. "solera," 800 kg. of briquetted soot and "vasisco" and a part of the soot of the previous run. From this charge 2140 kg. of metallic mercury were recovered with a fuel consumption of 18 metric centners[5] of coal. Occasionally coke fuel is used, of which only 12 q. are used, since the preliminary heating is done by 1 metric centner of wood and 2 metric centners of coal. Two firemen control the operation. One foreman, 2 bosses, 6 men to charge the furnace and 2 to lute the aludels are necessary for a clean-up.

Cermak Furnaces and Condensers

Cyarzabal, when manager of the plant, introduced a Livermore furnace in order to increase the capacity of the plant for treating fines. This furnace was in operation until the year 1903, when it was replaced by three fine-ore furnaces of the Cermak-Spirek system[6].

In order to treat the low-grade coarse ore successfully, two twin-shaft furnaces of Spirek's design were erected. Both types of furnace are equipped with primitive Cermak condensers called "canos curvos y canos rectos," which are made locally of reinforced concrete (Fig. 3). The cooling of these condensers is poor because of the lack of water. They lead to a common flue from which a blower discharges the gases to the stack. This part of the plant, contained in a large new building, is situated at the highest elevation of the works, and gives the impression of being modern, even

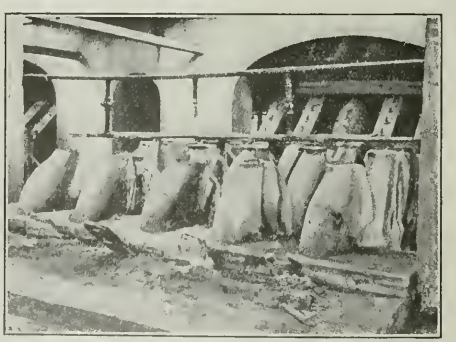


FIG. 3. CERMAK CONDENSER AT ALMADEN

though it is poorly kept up. The performance of these furnaces is considered excellent, but a thorough reform of the entire plant practice is not even thought of because the richness of the ore bodies allows any amount of waste and because laws safeguarding the health of the workingmen do not seem to exist.

The three "hornos de menudo," that is, the iron-sheathed, fine-ore furnaces, two of which have a ca-

[5] (Translator's note.) Metric centner, also called double centner = one quintal (q) = 100 kg. = 220.5 lb.

[6] Schnabel Handbook of Metallurgy, Vol. 2, p. 393. The Mineral Industry, New York, 1898 to 1902. Jahrbuch der Bergakademien, Vienna, 1900. Berichte der Weltausstellungen, Paris, 1899 to 1900. Z. f. angew. Chem., 1901 to 1905. Annales des Mines Belgique, Tom. IX, 1904. Congres international des mines, de la metallurgie, etc., Liege 25, 6, 1905. La metallurgia del mercurio VI. Congresso Internationale della chimica applicata, Rom, 1906.

pacity of 8 metric tons per 24 hours, the other 4 metric tons per 24 hours, treat 20,000 kg. "vasisco," passing a 5-cm. screen with a fuel consumption of 166 kg. of coal. The "hornos de torre," or shaft furnaces, treat 28,000 kg. "solera," with a fuel consumption of 650 kg. of coke. Eight men operate the furnaces in eight-hour shifts. The fine-ore furnaces have a special exit pipe to draw off the mercury fumes, or "vasos," from under the top row of tile, and the shaft furnaces are provided with double-charge doors. Despite these precautions the charge is never free from fume, and a halfway breathable atmosphere can only be maintained on the charge floor when the hopper is filled with a layer of "vasisco" after each charge. The ore is so rich that a continuous stream of quicksilver flows from the condensers to the storeroom. The soot is gathered into boxes during the clean-up and worked with a hoe called "rodillo." The soot-rejects are mixed with "vasisco," briquetted and burned in the Bustamente furnace, or it is added to the shaft-furnace charge. In the future it is proposed to press the soot-rejects in a cylindrical form so that they can be treated in quantity with the lump ore. The clean-ups, or "limpios," are run once a year, that is, when the "campana" is completed and repairs are undertaken; this is done in the beginning of May. These "limpios" net about 27,000 kg. of metal.

Production and Costs

The mercury stored in the storeroom is shipped in seamless Mannesmann-steel bottles which are manufactured by the Domingo de Orneta Co., at a price of 6 pesetas 10 centimos each ($1.20). Generally, old bottles that have been redeemed in London and sent back to Almaden are used. A counterbalanced sheet-iron funnel having an iron draincock serves as a weighing bucket. It is filled with 34.507 kg. of mercury[1]. This mercury is drained into the flask, which when stoppered, is ready for market.

The future production of Almaden will be on the same scale as in the past. The total production of Almaden, according to the statistics at the works, is 5,089,041 flasks. Despite these favorable conditions, the production costs at Almaden are the highest. The cost of 138 pesetas ($26.63) per ton of ore treated (figures for 1905 as given by the Revista minera, etc.) shows their production cost to be seven times as great as at Idria, where the ore is only one-tenth as rich.

Statistics of Production

According to the statistics of the Frankfurter Metallurgische Gesellschaft, the following is the production of Spain, which includes that of Asturia and other minor sources:

	Metric Tons
1900	1095
1901	754
1902	1425
1903	968
1904	1130
1905	853
1906	1567
1907	1212
1908	1068
1909	1393
1910	1114
1911	1486
1912	1490

The last figure (1490 metric tons) equals 43,800 flasks of 75 lb. (29.4 flasks of 75 lb. per metric ton).

[1]Old Spanish centner = 76 lb.

Notes on the Chemical Analysis of Red Lead

By W. F. Edwards
Studebaker Corporation, Detroit, Mich.

RED LEAD is an important industrial material of varying content of "true red lead," Pb_3O_4, and litharge, PbO, together with small per cents of metallic lead. A Navy Department specification calls for 94 per cent "true red lead," the balance to be practically pure lead monoxide, not more than 0.1 per cent of metallic lead being permissible.

Direct methods for determining the amounts of "free" lead monoxide (litharge) and metallic lead are usually not given in schemes for the analysis of red lead, and there is a variety of methods given by different authorities on paint analysis for the determination of the "true red lead."

All schemes for the analysis of red lead base the determination of the "true red lead," assumed to be $PbO, 2PbO$, on the oxidizing action of the PbO_2 part on such substances as oxalic acid, potassium iodide, ammonium ferrous sulphate, stannous chloride, etc.

The "tentative method" of the American Society for Testing Materials uses potassium iodide, following the method of Diehl as modified by Topf. By taking the usual precautions against the loss of iodine this method gives consistent results in the analysis of dry red lead.

The method briefly stated is: 1 gram of red lead is rubbed to a paste with a few drops of water and a cool mixture of 30 grams of crystallized sodium acetate, 2.4 grams of potassium iodide and 10 cc. of water and 10 cc. of 50 per cent acetic acid are added and stirred until the red lead is dissolved, when 30 cc. of water and 5 grams of sodium acetate are added. The mixture is then cooled to room temperature and titrated immediately with N/10 sodium thiosulphate.

Stock Solution Saves Time

Much time may be saved and quite as accurate analyses obtained by using a stock solution of the mixture of sodium acetate, potassium iodide and acetic acid; and also of the water and sodium acetate. The stock solution containing the potassium iodide will of course in time decompose somewhat, but the error is too small to notice unless the solution has been kept a long time in a warm place and exposed to sunlight. A blank titration run in parallel on the stock solution, or the standardization of the sodium thiosulphate on a standard sample of red lead, will insure against error. Sabin in his "Technology of Paint and Varnish" gives a formula for making up the stock solution of sodium acetate and potassium iodide with 50 per cent acetic acid.

The writer has obtained excellent results by using a stock solution made up with ammonium acetate instead of sodium acetate; 600 grams of ammonium acetate and 60 grams of potassium iodide are made up to a volume of one liter by solution in 50 per cent acetic acid. This solution can be used in large excess without giving varying results, and it can be used on red lead to which has been added litharge, lead sulphate or zinc oxide or all three together.

To try this out a series of 0.5 gram samples of a standard sample of red lead were weighed out and several

were titrated in the usual way and several more after additions of varying portions of litharge, up to ½ gram, were added; several more after varying proportions of lead sulphate, up to ½ gram, were added; and several more after varying proportions of zinc oxide, up to ½ gram, were added. The red lead was found to be the same in all cases, showing that the added substances had no effect on the per cent of "true red lead" found.

A second similar set of analyses was run using sodium acetate stock solution made up according to Sabin. These analyses showed that the added substances have no effect. However, I found the per cent of "true red lead" consistently a very little higher than was obtained by the solution made up with ammonium acetate.

It is not necessary to wait until all the red lead dissolves when using the ammonium acetate solution; ½ gram of finely divided red lead will dissolve in 25 cc. of the stock solution in less than one minute by stirring cold. It is a good plan to run in the thiosulphate solution fast enough to keep the solution a pale yellow color while the red lead is dissolving. After the ½ gram of red lead is weighed out two minutes is all the time required for making the titration. It is a speedy and satisfactory estimation for dry red lead.

It does not give satisfactory results on red lead that has been mixed with oil. It seems impossible to free the red lead entirely from the oil. In ordinary cases of separation from oil there will be enough oil adherring to the red lead so that 2N nitric acid will dissolve the red lead completely.

Analytical Equations

The analytical equations that represent the reactions for the purpose of computation are:

(1) $Pb_3O_4 + 8KI + HC_2H_3O_2 + NaC_2H_3O_2 + XH_2O = 3PbI_2 + 2I + (n—8)\ HC_2H_3O_2 + 8KC_2H_3O_2 + NaC_2H_3O_2 + (X + 4)\ H_2O$.

(2) $2I + Na_2S_2O_3 = 2NaI + Na_2S_2O_6$. 2×126.92 parts iodine are equivalent to $(3 \times 207.2) + (4 \times 16)$ parts of red lead. Therefore the iodine value of the thiosulphate used multiplied by 2.6997 (practically 2.7) gives the amount of red lead in the sample used.

In applying the iodide method to peroxide of lead to see how closely it would check I used three different samples of peroxide from a manufacturer of analyzed chemicals for reagent and made a discovery that is worth recording. The three samples were in their original bottles with the labels and lot number of the manufacturer. The labels gave the amount of certain impurities, but only one gave the PbO_2 content. One sample contained less than fifty per cent PbO_2, one a little over sixty per cent PbO_2 and the third about ninety-five per cent PbO_2. This third sample gave the per cent of PbO_2 which checked quite closely with my analysis.

Methods Used as Checks

Toch in his "Technology of Paints" gives first place to the oxalic acid and permanganate of potassium volumetric method of Lux for estimating the "true red lead." The writer has used this method in check against the potassium iodide and sodium thiosulphate volumetric method on the same sample and mixtures and has found it to check as nearly as could be expected; in fact, my checks were so close as to throw doubt on my work, the iodide method giving 95.98 per cent and the oxalic acid method giving 96.01 per cent "true red lead," the highest variation in either case being eight points in the second decimal place.

The oxalic acid method is carried out as follows: 0.5 gram red lead is brought to the boiling temperature in 30 cc. of 2N nitric acid, and 25 cc. of N/5 oxalic acid are added and again brought to a boiling temperature and titrated with N/10 or N/5 potassium permanganate solution, to determine the excess of oxalic acid solution used.

It requires a little practice to know the end of the reaction, but this once learned, it is a very satisfactory method. The solutions are all easy to make and they keep well.

This method, like the iodide method, was not capable of giving consistent results in my hands on red lead after it was mixed with oil, no matter how carefully it was extracted to remove the oil.

The writer would modify the procedure so as to use both N/10 oxalic acid and N/10 permanganate whenever a high degree of accuracy is desired.

More Analytical Equations

The analytical equations for the purpose of computation are:

(1) $Pb_3O_4 + nHNO_3 + mH_2C_2O_4 + XH_2O = 3Pb(NO_3)_2 + (n—6)\ HNO_3 + (m—1)\ H_2C_2O_4 + 2CO_2 + (X + 4)\ H_2O$.

(2) $5H_2C_2O_4 + 2KMnO_4 + nHNO_3 + XH_2O = 2KNO_3 + 2Mn(NO_3)_2 + 10CO_2 + (N—6)\ HNO_3 + (X + 8)\ H_2O$.

685.6 Pb_3O_4 equivalent to 90.01 $H_2C_2O_4$. The value of oxalic acid consumed in the solution of the Pb_3O_4 multiplied by 7.62 gives the Pb_3O_4 in the sample used.

Holly in his "Analysis of Paint and Varnish Products" obtains the peroxide content of red lead by the method of Mannhardt, which is carried out in the main as follows: 1 gram of red lead is triturated with accurately weighed 1.176 grams of crystallized ammonium ferrous sulphate, then ten grains of ammonium chloride is added and the mixture moistened with a few drops of water and the whole rubbed together after which 20 cc. water and 20 cc. concentrated hydrochloric acid are added and then all is heated on the steam plate and titrated with 3N/10 potassium bichromate solution.

The writer was not favorably impressed with the manipulations in this method and considered a 3N/10 solution too concentrated, though concordant results were obtained on samples of dry red lead.

Modification for Daily Use

The following modification of this method for use where a number of samples are to be estimated daily works out very satisfactorily, giving consistent results, and being easily carried out, the most unsatisfactory thing about it being the use of an outside indicator.

Stock solution sufficient for the day's use of N/10 ammonium ferrous sulphate is made by dissolving 39.214 grams of the sulphate in 5N ammonium chloride to make a liter of solution.

The hydrochloric acid cannot be added to this solution without precipitation of the ammonium chloride. Therefore, the hydrochloric acid must be added after the red

lead has been mixed with the stock solution. To carry out the analysis with the stock solution 0.5 grams of red lead is moistened with a few drops of water and triturated, after which 25 cc. of stock solution and 25 cc. of concentrated hydrochloric acid are added. The mixture is stirred while heated until the red lead is decomposed, when it is titrated with N/10 potassium dichromate to determine the excess of ammonium ferrous sulphate used.

The analytical equations representing these reactions for the purpose of computation are:—

(1) $2\ (NH_4)_2SO_4\ FeSO_4\ 6H_2O + n\text{HCl} + Pb_3O_4 + m\ NH_4Cl + XH_2O = Fe_2(SO_4)_3 + (NH_4)_2SO_4 + 3PbCl_2 + (n - 8)\ HCl + (M + 2)\ NH_4Cl + (X + 16)\ H_2O.$

(2) $6\ (NH_4)_2SO_4\ FeSO_4\ 6H_2O + K_2Cr_2O_7 + NH_4Cl + XH_2O = 3Fe_2(SO_4)_3 + 12\ NH_4Cl + 2KCl + Cr_2(SO_4)_3 + (N - 14)\ HCl + (X + 43)\ H_2O.$

Each cubic centimeter of the ammonium ferrous sulphate consumed in bringing the red lead into solution is equivalent to 0.03428 gram of "true red lead."

"Rapid and Accurate" Volumetric Method

In the 1910 edition of "Stillman's Engineering Chemistry" a "rapid and accurate" volumetric method of determining "true red lead" in red lead by the use of stannous chloride as the reducing agent is described as carried out by Wainwright. It is repeated in the 1916 edition, indicating that it has been found satisfactory.

N/10 iodine solution and a solution of 14.1 grams stannous chloride in water to make one liter are used. The iodine value of the stannous chloride solution is formed under conditions identical with those used in the analysis.

In the analysis one gram of red lead is moistened with water and 25 cc. of the stannous chloride and 40 cc. of concentrated hydrochloric acid are run in, and boiled until the red lead is in solution, 100 cc. cold water added and further cooled and titrated with N/10 iodine solution to determine the excess of stannous chloride used.

Only Objection Is Overcome

The only objection to this method is the boiling and cooling of the solutions, and that the value of the stannous chloride must be found under practically identical conditions of boiling and cooling with those used in the analysis.

In order to do away with this difficulty N/10 stannous chloride in N/2 hydrochloric acid was used; 0.5 gram of red lead was moistened with water and triturated until the red lead is all very finely divided (this is the condition to success), 25 cc. N/10 stannous chloride run in and stirred, then 25 cc. concentrated hydrochloric acid are added and the whole stirred until all but some white particles is dissolved and then titrated cold with N/10 iodine. The end reaction is sharp, no heating is required and the results are consistent to a high degree of accuracy.

The method also worked well on peroxide of lead, it being only necessary to double the quantities of stannous chloride solution and hydrochloric acid.

Any one of the four methods is capable of consistent and practically accurate determination of "true red lead" in commercial red lead. The writer is inclined to the use of the stannous chloride method of Wainwright, with the modifications given in this paper.

Institute of Chemical Engineers

FOLLOWING is the program as officially announced for the eleventh annual meeting of the American Institute of Chemical Engineers to be held Jan. 15 to 18, 1919, in Chicago:

Wednesday, Jan. 15

9:00 A.M.—Registration of members at Congress Hotel.

9:30 A.M.—Address of Welcome — Mr. Leonard Busby, president Chicago surface lines.
Response by President Thompson.
Business Session.

11:00 A.M.—Address of President Thompson, "Chemical Industries Made Permanent."
Symposium on Maintenance and Preservation of Our Chemical Industries: Résumé of Conditions as They Exist at Present," M. Toch; "Recommendations of the Tariff Commission in Regard to Dyes and Coal Tar Chemicals," Dr. Grinell Jones of the U. S. Tariff Commission.

12:30 P.M.—Complimentary Luncheon at Congress Hotel. The Chicago members of the Institute will entertain all visiting members and guests.

2:00 P.M.—Symposium on Maintenance and Preservation of Our Chemical Industries, continued: Addresses by the following representatives of chemical manufacturers: Dr. Louis Matos of the National Aniline & Chemical Co., Robert Hilton of the Ault & Weiborg Co., Dr. A. A. L. Veillon of the Monsanto Chemical Co., O. Dill of Perth Amboy Chemical Works.
Discussion by representatives of other chemical industries.

8:00 P.M.—Reading of Papers: "Future of the Barium Industry," Wm. H. Rollin of the Rollin Chemical Co.; "Reconstruction Aspects of Some Chemical Industries of the United States," Dr. Edward Gudeman.

9:00 P.M.—Smoker.
Members of the Chicago section of the American Chemical Society will be the guests of the evening.

Thursday, Jan. 16

9:30 A.M.—Members will leave the Congress Hotel by auto at 9:30 A.M. for the Union Depot to take a special C. & A. train to Argo, Ill., to visit the plant of the Corn Products Refining Co. Luncheon will be served at the plant and the return trip will bring members back to the Congress Hotel at about 5 P.M.

8:00 P.M.—Joint meeting with local section of the American Chemical Society. "Present Status of Nitrogen Fixation," Lieut. Col. Alfred H. White. Illustrated by lantern slides.

Friday, Jan. 17

9:30 A.M.—Business Session.

10:30 A.M.—Reading of Papers: "Reinforced Concrete Tanks for Storing Ammonia Liquors, "F. W. Frerichs; "Some Wild Engineering I Have Known," David Wesson; "Belting for Power Transmission," Ernest D. Wilson.

12:00 M. —Complimentary Luncheon.

1:30 P.M.—Excursions.
Members and their guests will proceed by autos to the plant of the Lindsay Light Co. to inspect the preparation of rare earths and the manufacture of gas mantles.
Visit to the Underwriters' Laboratories of Chicago, where special demonstrations will be made.

7:00 P.M.—Subscription Dinner at Congress Hotel.

Saturday, Jan. 18

8:00 A.M.—Standard Oil Co., Whiting, Ind.

Census of Chemical Imports

THE census of chemical imports, which for the past ten months has been under preparation for the Bureau of Foreign and Domestic Commerce, has been completed. The necessity for this census was apparent immediately subsequent to the beginning of the European war. Its need for domestic chemical manufacturers was considered by the American Chemical Society in 1915 and a committee was designated by that society to procure it. After a conference by this committee with the Chief of the Bureau of Foreign and Domestic Commerce in November, 1917, the necessary steps were taken for the promulgation of the Census of Chemical Imports, stating therein quantity and value, and percentage by quantity of all products consumed in or produced by chemical and allied industries and imported into this country during the fiscal year 1913-14.

The census was commenced in March, 1918, and during most of the time since as many as twenty-four clerks have been employed in securing these voluminous statistics. The census shows in detail every chemical and allied chemical, drug and medicine imported into this country during the fiscal year July 1, 1913, to June 30, 1914, together with the quantity, value and percentage by the country of origin of each of these articles. Incorporated in the census is detailed information concerning 2500 articles having an entered value in excess of $100, and an alphabetical list of 4000 articles having an entered value less than $100. The total import value for the fiscal year 1913-14 of all the articles enumerated in the census is in excess of $268,000,000.

The principal classes of articles included in the census are: Chemicals, drugs, medicines, coal tar products, vegetable oils, animal oils, essential oils, perfumes, perfumery materials, cosmetics, toilet preparations, paints, pigments and varnishes, dyeing and tanning materials, fertilizers and soaps. Embodied in the census is information showing the distribution according to the countries of origin of these different articles considered by classes.

The Census of Chemical Imports will be published by the Government Printing Office by Feb. 1, and will then be ready for public distribution.

Production of Lead Pigment in the U. S.

According to statistics compiled in the United States Geological Survey, Department of the Interior, the total value of lead pigments of domestic manufacture sold in the United States in 1917 amounted to $36,663,923, as compared with $31,061,589 in 1916 and $24,614,006 in 1915. The quantities marketed, however, decreased steadily, as shown in the following table:

	1917		1916		1915	
Pigment	Quantity (Short Tons)	Value	Quantity (Short Tons)	Value	Quantity (Short Tons)	Value
White lead:						
In oil...	87,331	$17,608,967	96,041	$16,560,137	122,194	$15,879,835
Dry....	27,869	4,920,864	32,938	4,714,343	33,907	3,513,856
Red lead..	25,478	5,523,018	23,035	3,933,566	19,435	2,397,900
Litharge..	44,102	8,611,074	37,739	5,853,543	26,118	2,822,415
	184,780	$36,663,923	189,753	$31,061,589	201,654	$24,614,006

The abnormal conditions created by the war manifestly reacted strongly upon the lead-pigment industry. The high cost of everything that enters into the cost of manufacturing and marketing the product is reflected in the increased value.

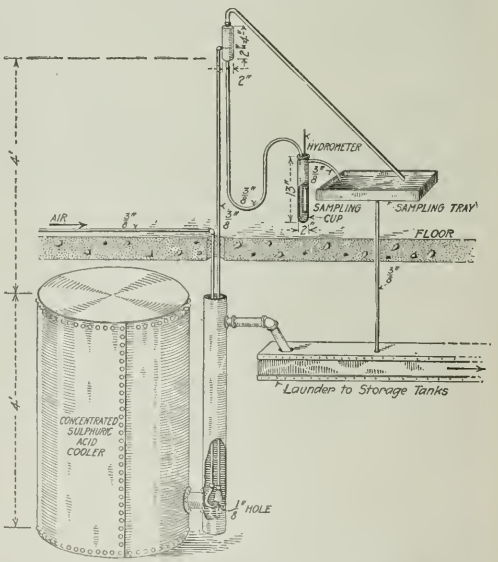
Continuous Sulphuric Acid Sampler

By S. A. Ionides

AT THE British Acetones plant in Toronto two 30-ton Chemical Construction Co. Gilchrist towers were installed to reconcentrate the sulphuric acid diluted in the regular operation there. The coolers for the concentrated acid were located between the towers below the main operating floor. Control of operation depended largely on the Baumé readings of the discharged concentrated acid, which were made each hour by dipping samples from the discharge pipe of the cooler, setting the dipper on a sampling tray and inserting a hydrometer. This operation was clumsy. Acid was apt to be splashed over the clothes of the operators, the mortality of the hydrometers was high and there was no inducement to take readings except at the regular time each hour, and with careless operating appreciable changes took place unnoticed between readings.

To remedy this situation, the simple continuous sampling device, illustrated here, was installed. It consisted essentially of a miniature air lift and as the acid was almost always below 60 deg. B., it was made entirely of lead.

The length of the upward discharge pipe from the cooler was 4 feet, and the acid had to be raised four feet further for convenient observation, which constituted a suitable ratio for an air lift. Three-eighths internal diameter lead pipe was used, that being the



CONTINUOUS SAMPLER FOR SULPHURIC ACID CONCENTRATOR

smallest size lead pipe readily available. The nozzle of the air pipe was reduced to one-eighth inch. The air pipe was connected to the air supply used for agitating the acid in the concentrators and it required only a minute flow of air to give a steady, small flow of acid up the lift and through the sampling cup. The separating head first installed allowed a little froth to come over with the air outlet, so the outlet pipe was bent

over as shown to discharge this into the sampling tray which was already installed. For the second tower the sampling head shown in the sketch was used, but the armistice was signed and the plant shut down before it was put into operation.

A slight froth formed on the surface of the sampling cup in the first installation, which at times tended to obscure the reading. To obviate this a trap was inserted between the separating head and the sampling cup in the second installation.

The important points in the construction of this apparatus were:

1. The relative diameters of the air nozzle and the riser pipe—one to three.
2. The position of the discharge pipe as near to the top of the sampling cup as possible for easy reading of the hydrometer.
3. The provision of some point at which the flow through the sampler could be observed to insure that a steady flow was passing through.

The advantages of this sampler were:

1. The ability to observe the Baumé of the discharged acid at any time.
2. The elimination of slashes of acid falling on the clothes of the operators.
3. The welcome and very marked reduction in the hydrometer casualty lists.

Patent was not applied for.

New Jersey Clay Workers Association Holds Meeting

THE fourth annual meeting of the New Jersey Clay Workers Association was held in the Queens Building, Rutgers College, New Brunswick, Dec. 17, with morning and afternoon sessions. President August Staudt, of the Perth Amboy Tile Works, Perth Amboy, presided at the morning meeting until the regular business session was concluded. New officers were elected for the ensuing year as follows: Charles Howell Cook, president Cook Pottery Co., Trenton, president; Abel Hansen, president Fords Porcelain Works, Perth Amboy, vice-president; and George H. Brown, director Department of Ceramics, Rutgers College, secretary and treasurer (re-elected). In the absence of Mr. Cook, Mr. Hansen presided for the remainder of the morning session.

Three interesting papers were presented in the forenoon, including "Some Defects in Terra Cotta," by D. F. Albery, Federal Terra Cotta Co., Woodbridge; "Sagger Mixtures," Professor George H. Brown, Rutgers College; and "The Effect of Some Fluxes in Porcelain," by F. H. Riddle, Bureau of Standards, Pittsburgh.

Professor Brown's paper covered the subject of sagger mixtures with great detail, embracing the character of sagger failures, properties of saggers, mechanical strength, hair cracks, resistance to deformation, as well as raw materials and composition. The paper was illustrated with interesting and illuminating charts.

Mr. Riddle's paper was illustrated with lantern slides, while a number of test specimens of porcelain were shown. The speaker made reference to the effect of such well-known fluxes as feldspar, magnesium oxide, calcium and barium. The clays used in the tests were from Florida, Delaware, North Carolina and Georgia; American clays exclusively were employed. The paper gave a number of interesting sidelights on the subject.

Following a recess for luncheon, the meeting reassembled, with President-elect Cook in the chair. Henry Kreisinger, Fuel Section of the United States Bureau of Mines, Pittsburgh, spoke on "Fuel Combustion"; Professor Carl B. Harrop, Department of Ceramic Engineering, Ohio State University, Columbus, gave an interesting address on "Future Kiln Developments," while a representative of the Philadelphia Textile Machinery Co., Philadelphia, spoke on the subject of "Solving One of the Clay Manufacturer's Greatest Problems," covering in detail the utility and value of the well-known Proctor drier manufactured by this company.

Professor Harrop's paper was an exhaustive study of car tunnel kilns, tracing the manufacture of different types of kilns of this style to the present time. He pointed out that the most successful tunnel kilns now in use were the American Dressler and the Didier-March, but that still much was desired in the way of greater perfection and efficiency. In tracing the employment of the tunnel kiln, he pointed out that after considerable investigation he had learned that such kilns had been developed as follows, some few in the list now having been practically forgotten:

Type	Number in Use
Anderson, 1891	1
Shaw, 1909	2
Didier-March, 1910	10
Dressler, 1915	19
Owens, 1916	11
Zwermann	1
Powell	1
Harbison-Walker	1
Total	46

This tabulation shows the extent of the use of car tunnel kilns in this country. The speaker urged greater simplicity in future kiln development, holding that there were great possibilities for the adaptation of an efficient kiln which allowed operation without the existing complications.

New Jersey Chemical Society

ON MONDAY evening, Dec. 9, 1918, the newly elected officers of the New Jersey Chemical Society assumed office. They are: President, Carleton Ellis, New Jersey Laboratories, Montclair, N. J.; vice-president, Frederic Dannerth, Consulting Chemist, Newark, N. J.; secretary, Herbert C. Cawley, the Harrison-Dupont Works, Newark, N. J.; treasurer, D. K. Howard; directors, R. P. Calvert, H. B. Baldwin, D. R. Hodgdon, W. A. Lucas, J. M. Reilly and W. G. Wright.

The scientific paper of the evening was presented by Dr. Alexander Smith of Columbia University, who spoke on "Some Common Errors in Chemical Text Books." The popular address was delivered by Mr. James M. Reilly, general secretary of the Board of Trade in Newark. He chose for his subject: "The Recent Developments of Chemical Industry in the State of New Jersey." The speaker referred to the tremendous growth of the plants which make chemicals for many different industrial processes. In this sense, the New Jersey industries are to a large extent "key industries." These include inorganic acids and alkalis, oil products, dyes and rubber-covered wire. Without them, the existence of many other general industries would be threatened. The

special guest of the evening was Lieut. J. V. Meigs, of the Edgewood Arsenal, Maryland, who spoke briefly of the production of poison gases for chemical warfare.

For Monday evening, Jan. 13, 1919, the Society has planned a "Rubber Night." An informal dinner will be held at the Achtel-Stetter Restaurant at 6 p.m. and the session will be held at the Newark Technical School at 8 p.m. New members will be admitted at that time.

The scientific paper will be by Mr. G. D. Kratz of Cuyahoga Falls, Ohio, on "The Application of the Principles of Catalysis in the Manufacture of Rubber Goods" (a study of accelerators used in vulcanization).

The popular paper will be by Dr. Frederic Dannerth of Newark, N. J., on "Some American Substitutes for Rubber." There will be an exhibit of rubber goods and substitutes for rubber in the large auditorium of the school. The Rubber Association of America will hold its annual meeting and banquet in New York City in the same week, so that a large attendance of rubber experts from other States is expected at the January meeting.

The New Jersey Chemical Society was organized with the idea of bringing together the chemists of New Jersey, co-operating with various educational activities in northern New Jersey, and of bringing the chemical profession into prominence in that part of the State, as well as the general object of promoting discussion among the chemists. The secretary will be glad to receive applications for membership. Address H. C. Cawley, secretary, E. I. du Pont de Nemours & Co., 256 Vanderpool Street, Newark, N. J.

Meeting of Manufacturers' Council of New Jersey

CHEMICAL and affiliated interests were strongly represented at the special meeting of the Manufacturers' Council of the State of New Jersey, held at the Robert Treat Hotel, Newark, on Dec. 11. This convention, called for readjustment purposes, was the first gathering of its kind held by any state organization, and brought together about 250 delegates from all parts of the state. The meeting was called to order by Warren C. King, president of the King Chemical Co. and president of the Council, at 10:30 a.m. He told of the general purposes of the meeting and the aims to be accomplished and pointed out that the primary topics before the convention were labor, cancellation of war contracts, plant readjustment, compensation insurance and factory operation on a pre-war basis. He urged a consolidation of the different manufacturing interests of the state in a spirit of co-operation to bring about utmost co-ordination and thrift for individual and collective benefit.

In this connection, he urged the establishment of a State Industrial Commission to formulate definite plans for immediate action, devising a comprehensive program for concerted effort, and at the same time place itself in position to handle such individual problems as might arise. This recommendation was approved by the delegates assembled in a resolution covering the formation of a commission to be composed of five members each from manufacturing, financial, agricultural and public utility interests, as well as five members to represent labor engaged in manufacturing and public utility work, respectively, making a total of thirty members on the committee. The personnel of the State Industrial Commission will be announced at an early date.

The subject of labor and wage scales as now operative occupied considerable discussion at the different sessions. It was pointed out that overtime must stop and the standard working day be placed into effect. Representatives of labor present at the meeting expressed full accord with these sentiments. A resolution was adopted reading, "It is the sense of this convention that there should be no radical reduction in the present scale of wages until the purchasing power of the dollar increases and in any event wages should be the last thing cut in any readjustment." Addresses on the subject of labor and wages were made by Arthur A. Quinn and Henry F. Hilfers, president and secretary, respectively, of the New Jersey State Federation of Labor.

Important addresses were made at the morning session by John D. Everett, former president New Jersey State Bankers' Association; Dr. J. G. Lipman, dean and director New Jersey Agricultural Experiment Stations, and Myrza Ali Kula Khan, Persian Minister to the United States. The afternoon was devoted to group meetings of manufacturers, banking, agricultural and labor interests, with a reassembling of the full convention for the adoption of final resolutions before the close of the day.

A banquet was given in the evening in the ballroom of the hotel, Mr. King acting as toastmaster. Among the speakers were W. H. Besler, president of the Central Railroad of New Jersey; Dr. W. H. S. Demarest, president Rutgers College, and Dr. Alexander C. Humphreys, president Stevens Institute of Technology. Col. Austen Colgate, first vice-president of the Council, who presided at the afternoon business session, was expected to address the evening gathering, but was unable to be present.

The Council has a membership of over 120 prominent concerns in the state at the present time. Among the chemical and affiliated industries now represented in the organization are: Central Dyestuff & Chemical Co., Newark; United States Metals Refining Co., Chrome; Ajax Rubber Co., Trenton; American Color Mfg. Co., Passaic; Barnes Chemical Works, Paterson; Yatman Rubber Co., Newark; United & Globe Rubber Mfg. Co., Trenton; Star Porcelain Co., Trenton; E. R. Squibb & Sons, New Brunswick, chemicals; Raritan Copper Works, Perth Amboy; Paterson Parchment Paper Co., Paterson; King Chemical Co., Bound Brook; American Oil & Supply Co., Newark; Anderson Chemical Co., Wallington; Armstrong Cork Co., Camden; J. T. Baker Chemical Co., Phillipsburg; Braender Rubber & Tire Co., Rutherford; Bulls Ferry Chemical Co., Edgewater; Columbus Crystal Co., Newark; Condensite Co. of America, Bloomfield; Charles Cooper & Co., New York, chemicals; Cumberland Glass Mfg. Co., Bridgeton; Delion Tire & Rubber Co., Trenton; Dexter Metal Mfg. Co., Camden; Didier-March Co., Perth Amboy; E. I. du Pont de Nemours & Co., Haskell; Fords Porcelain Works, Perth Amboy; Gaynor Glass Co., Salem; Howe Rubber Co., New Brunswick; R. M. Hollingshead Co., Camden, chemicals; and J. L. Mott Co., Trenton.

Personal

PROF. FRED W. ASHTON has been granted a leave of absence by the University of the Philippines and has taken over new duties as carbonization supervisor with the Chemical Warfare Service at Manila, P. I.

MR. VERNE W. AUBEL, who recently returned from blast furnace work in Australia and New Zealand, has been appointed assistant superintendent of blast furnaces at the Clairton, Pa., plant of the Carnegie Steel Co.

DR. SERGIO BAGNARA has resigned as metallurgical engineer of the Ordnance Department, U. S. A., and will locate in New York temporarily.

MR. E. H. BEDELL, who left CHEMICAL & METALLURGICAL ENGINEERING on Aug. 10 to serve in the Ordnance Department, returned on Jan. 1 to resume his former duties as Eastern Representative in the Advertising Department.

DR. GEORGE W. COGGESHALL, who has been serving with the Emergency Fleet Corporation, has resigned, and will return to his duties as a member of the staff of the Institute of Industrial Research, Washington, D. C. Dr. Coggeshall specialized during the war on concrete-ship construction, including oilproofing and waterproofing.

DR ALLERTON S. CUSHMAN has just received his honorable discharge as Lieutenant-Colonel in the Ordnance Department, U. S. A. For eighteen months he had charge of the research and chemical laboratories, including the explosives activities, at Frankford Arsenal, Pa., where he was engaged principally on ammunition and metallurgical problems. Dr. Cushman now returns to his former professional activities as head of the Institute of Industrial Research, Washington, D. C.

MR. C. T. HENDERSON has resigned as chief engineer of the Submarine Boat Corporation, Port Newark Terminal, Newark, N. J., and has accepted a similar position with the Hercules Engineering Corporation, 501 Fifth Avenue, New York. He also acts as president of the Electrolytic Engineering Corporation at the same address.

MR. ARTHUR J. HOSKIN, consulting engineer of Denver, Colo., has returned after a three-months' stay in Dillon, Mont., where he was engaged in installing an oil-shale plant.

MR. S. A. IONIDES has resigned from the British Acetones Toronto, Ltd., and intends to open up his office in Denver again as a metallurgical and chemical engineer.

MR. J. J. MCKEE, formerly New York manager of the C. A. Dunham Co. of Marshalltown, Ia., has accepted a position with the Machinery Utilities Co., 501 Fifth Avenue, New York.

MR. FRANK PURNELL, assistant to Mr. J. REPLOGLE, director of steel supply at Washington, has returned to the sales department of the Youngstown Sheet & Tube Co., Youngstown, O. Mr. Purnell was called to Washington fifteen months ago and has served in various capacities in the steel section.

MR. P. B. SADTLER, vice-president of the Swenson Evaporator Co., Chicago, Ill., who has been operated on for appendicitis, expects to return to his duties shortly after the first of the year.

MR. R. B. SAUSEN has become identified with the Star Brass Works of Chicago, Ill., and engaged in sales promotion and research work of spray cooling equipment. He was formerly district manager of the Chicago office for the Schutte & Koerting Co., of Philadelphia, Pa.

MR. HORACE V. WINCHELL has been nominated for president of the American Institute of Mining Engineers.

MR. O. WISER, for several years the assistant superintendent of the Hurley (N. M.) mill of the Chino Copper Company, has recently resigned to become president of the Republic Mining & Milling Co., with offices at Hurley and operations at Hanover. Mr. O. F. RISER is now assistant superintendent of the Chino mill.

Obituary

MR. WILLIAM GARRIGUE died of pneumonia at Toronto, Ont., Oct. 2, 1918. By his death the chemical engineering profession and the chemical industry suffered a distinct loss. Mr. Garrigue had particularly identified himself with the soap and glycerine industry and the equipment

MR. WILLIAM GARRIGUE

designed and built by his firm, William Garrigue & Co., is in use by firms throughout this line of manufacture. Mr. Garrigue was born at Copenhagen, Denmark, in 1872. He came to the United States when a child with his parents, who settled in New York City. His father, Dr. Henry J. Garrigue, was a prominent physician and writer on medical subjects. Mr. Garrigue was educated in the public schools of New York, later taking special courses at Columbia University in chemistry and studying chemistry under a private tutor in the laboratory of one of the best analytical chemists of that day in New York. After completing his education Mr. Garrigue's love of adventure and outdoor life led him to the Far West, where he soon became interested in mining. From there he went to Pittsburgh and opened a consulting and testing laboratory. About this time he became connected with the firm of W. & H. Walker, Herr's Island, Pittsburgh, who were interested in greases, oils, soaps, etc. Mr. Garrigue soon established himself as an expert in this field, which from that time on formed his sole line of activity. He acted as consulting and designing engineer for soap and glycerine equipment, maintaining offices in Detroit, Louisville, New Orleans and finally in New York and Chicago. Mr. Garrigue's principal contributions to industrial chemistry were the following: 1. The principle of double effect glycerine distillation. This was a process for distilling glycerine which has largely taken the place of the Jobbins still, previously the leading equipment. The vapor from the concentrator is used as the injected live steam for the still. This does away with using fresh superheated steam and contributes greatly to the economy of the operation. 2. Separation of trimethyleneglycol from glycerine. 3. The recovery of dynamite glycerine from cotton-seed soap stock spent lyes. 4. Reversible double effect evaporation for spent soap lye. 5. The combined evaporation of caustic soda, lye and spent soap lye in triple effect. 6. Direct autoclaving of cotton-seed soap stock before distilling fatty acids. Also decided improvements in the construction of vacuum evaporators and solvent extractors. In addition to his work in the soap and glycerine industry, Mr. Garrigue designed and built

an interesting plant for the recovery of potash from molasses distillery slop at Harvey, La., and also a complete garbage reduction plant for the city of Erie, Pa. Mr. Garrigue was a member of the American Chemical Society, the American Institute of Chemical Engineers, the Chemists' Club of New York, the New Orleans Country Club, and the Southern Yacht Club, New Orleans. His interests were by no means limited to his profession. He was one of those men who regard education as a process that should last throughout a man's life. Regardless of whether science, literature, politics or art was the subject of the conversation, he would have some idea or some new point of view to contribute that would be interesting and helpful. The feeling of loss on the part of those who knew him intimately occasioned by his sudden and unexpected death is a very real one.

Mr. William H. Stubblebine, inventor of the Stubblebine furnace, died at his home in Allentown, Pa., Dec. 6, aged 78 years. He was born in Reading, Pa., saw service in the Civil War, and on his retirement from the army in 1863 located at Bethlehem, Pa. He became one of the associates of the late John Fritz in developing the activities of the Bethlehem Iron Co., now the Bethlehem Steel Co. In 1875 he was appointed superintendent of the merchant department and in 1907 he retired. He leaves a son, W. A. Stubblebine, and two daughters.

Mr. Emerson H. Strickler, manager of the inorganic research department of the General Chemical Co., died on Nov. 22. Mr. Strickler's most recent and conspicuous achievement was the conception and development of Ryzon baking powder.

Dr. Harry Percival Corliss, until recently an Industrial Fellow in the Mellon Institute of Industrial Research, University of Pittsburgh, died at Ray, Arizona, on Nov. 16, of pneumonia following influenza, as mentioned in our Dec. 15 issue. Funeral services were held on Dec. 23 at the First Congregational Church of Wolfeboro, N. H., where his parents, Charles H. and Mary A. Corliss, are now living. He is survived by his wife, Marion Pilkey Corliss, and a sister, Mrs. Donna Nickerson. Dr. Corliss was born at Thornton, N. H., Oct. 21, 1886. He attended Brewster Academy at Wolfeboro, and was graduated in 1910 from New Hampshire State College with the degree of Bachelor of Science in Chemical Engineering. He then continued the study of chemistry at the University of Toronto, specializing in physical and organic chemistry. In July, 1912, he accepted a position as Industrial Fellow at the Mellon Institute, and in 1913 received the degree of Doctor of Philosophy from the University of Pittsburgh. Dr. Corliss' work at the Mellon Institute extended over a period of five years, during most of which time he was engaged in physical, chemical and metallurgical research. This research resulted in the development of several important improvements upon the flotation process for the recovery of minerals. Perhaps his greatest contribution to this industry was the discovery of alpha-naphthylamine as a flotation agent. It is too early as yet to estimate the full value of this discovery, but the excellent practical results already following its use warrant the belief that the work of Dr. Corliss will eventually be recognized as being of first importance in this field. In July, 1917, he accepted a position as chemical and metallurgical engineer with the Metals Recovery Co. in order to initiate the large scale application of his discoveries in the flotation mills of the Southwest. In this work he was uniformly successful and was rapidly making for himself an enviable reputation as a metallurgical engineer when death called him. From his boyhood up, Dr. Corliss' associates recognized in him the qualities of marked intellectual brilliancy and very real moral worth. All through his student days the highest scholastic honors came to him without conscious effort on his part because he loved the study of chemistry in all its branches. He brought the same qualities of mind and spirit to his research work at the Mellon Institute and to its extension in the wider fields of industrial application. His many friends will feel that by his death the world was deprived of a life which held unusual possibilities for useful work and high accomplishment.

Mr. Henry Edward Randall, Jr., died on Oct. 21, aged 25 years. His death occurred after an illness of one week at Montreal General Hospital as a result of pneumonia, following an attack of influenza. Mr. Randall was a native of Vermont, was graduated at Massachusetts Institute of Technology in 1913 and immediately accepted a position with the Shawinigan Water and Power Co. of Canada, with which company he was affiliated for five years in various branches of their system—with the North Shore Power Co. of Three Rivers, Quebec, as power sales engineer and assistant to the vice-president in Montreal, and as

HENRY EDWARD RANDALL, JR.

general manager of subsidiary companies. He possessed high ideals of serving his country in an industrial way during the war and was one of the most successful captains in the Montreal Victory Loan drive of November, 1917. On Oct. 1, 1918, Mr. Randall became general manager of the Ludlum Electric Furnace Corporation and removed to New York. He was also consulting engineer for the Canadian Ferro-Alloys Co. in Shawinigan Falls, Quebec. Mr. Randall was a member of the American Illuminating Electrical Engineering Society, American Electrochemical Society, American Foundrymen's Association, Canadian Society of Civil Engineers, Canadian Electrical Association, Engineers' Club of Montreal, Marmier Club of Canada and Phi Delta Theta Fraternity.

Current Market Reports

The Non-Ferrous Metal Market

Saturday, Dec. 28. — Prices are declining. In general consumers are not adding to stocks, with a result that all markets are dull at present. Major transactions are expected after New Year's.

Aluminium:—The Government prices on ingots 98 to 99 per cent Al are $660 a ton f.o.b. plant in 50-ton lots; $662 down to 15-ton lots; and $666 down to 1-ton lots, which prices will continue the remainder of the year. Prices per pound for small lots vary from 40c. to 45c.; sheet aluminium, 18 ga. and heavier, 42c.; powdered aluminium, 100 mesh, 70c.

Antimony:—Market continues to be dull with prices as low as 7½c. per lb.

Lead:—In common with the general trend, lead is declining in price, East St. Louis being $114 per ton. Small sales are being made at 6c. per lb. in New York; 5¾c. appears to be the probable objective.

Tin:—The tin market is not under domestic control and prices are generally dull at 72½c. per lb. Minor sales at 71c. have been reported, but the U. S. Steel Products Company has purchased 10,000 tons at 72½c., so that lower prices are not probable.

Copper:—The producers have agreed on a price of $460 per ton for carload lots. Large foreign sales are predicted, as this is believed to be a permanent price.

Copper sheets, hot rolled	lb.	$0.36 —	$0.37½
Copper sheets, cold rolled	lb.	.37 —	.38½
Copper bottoms	lb.	.44 —	.45½
Copper rods	lb.	.36 —	.37
Copper wire	lb.	.29½—	
High brass wire	lb.	.28½—	.29½
High brass sheets	lb.	.28½—	.29½
High brass rods	lb.	.26½—	.28½
Low brass wire	lb.	.32½—	.34½
Low brass sheets	lb.	.32½—	.34½
Low brass rods	lb.	.33½—	.35½
Brazed brass tubing	lb.	.37 —	.39
Brazed bronze tubing	lb.	.42½—	.44½
Seamless copper tubing	lb.	.41 —	.43
Seamless bronze tubing	lb	.45 —	.46
Seamless brass tubing	lb.	.37½—	.39½
Bronze (gold) powder	lb.	1.00 —	1.75

Tungsten:—The buyers of tungsten are decidedly cautious, though there is not likely to be any unlooked-for changes. Prices are nominal, scheelite bringing $25, wolframite, $20 to $21, with no sales of low grade reported.

Zinc:—Consumers are drawing on their stocks, making a dull market. Spot New York is quoted at $166 per ton; East St. Louis, December, $160 per ton; January, $151; February, $149, and March, $148.

OTHER METALS

Bismuth	lb.	$3.50—	$3.65
Cadmium	lb.	1.50—	
Cobalt	lb	2.50—	3.50
Magnesium	lb.	1.75—	2.10
Mercury	75 lb.	115.00—	
Mercury	lb.	1.95—	
Nickel	lb.	.40—	.43
Tungsten	lb.	34.00—	
Iridium	oz.	175.00—	
Palladium	oz.	135.00—	
Platinum	oz.	105.00—	108.00
Silver	oz.	1.01½—	

The Iron and Steel Market

The theory propounded in our last review, that iron and steel prices as established by Government control would be continued for an indefinite period because there was more to be gained by maintaining prices than by cutting them, has been borne out in substance though not in form Steel prices have been reduced, and for this our last review had this saving observation: "Of course there is the bare possibility of a new and lower level of prices being put out, perhaps under Steel Corporation leadership, in hope of the market being stabilized upon it, but that is extremely improbable." It was due to Judge Gary's courage and influence that what seemed extremely improbable actually occurred. As the machinery of Government price fixing had not been scrapped, the iron and steel industry had an opportunity to get together and discuss what recommendations it would make to the War Industries Board with respect to prices that might be named for the first quarter of the new year. It is stated that when the meeting opened about nine-tenths of those present were opposed to recommending that reductions be made. Through Judge Gary's leadership the meeting was led to passing, practically unanimously, a resolution empowering the general committee of the American Iron and Steel Institute to recommend price reductions. A definite schedule, it appears, had been formulated, but it was not presented at the meeting. When the committee met the War Industries Board according to an arrangement that had been made long before, there were mutual felicitations appropriate to the ending of the war, and then Judge Gary undertook to read the prepared memorandum of suggested price reductions. The chairman of the board's price fixing committee at once stated that it would not be desirable to have the suggestions read into the minutes and the meeting promptly adjourned. The statement was then given to the press.

Readjustment to a Peace-Time Basis

The object of the suggested reductions was to take a step in the direction of readjusting the iron and steel price structure to a peace-time basis, to set an example to the sellers of other commodities used in construction work so as to facilitate the resumption of construction operations and to furnish a basis for the adjustment of prices under such contracts for the sale of steel as otherwise would hardly be specified against. By making slight reductions the market would be stabilized and if the new prices were not low enough for the indefinite future declines would at any rate be postponed. The steel makers promptly adopted the suggested reductions for their part, but the blast furnaces have not adopted the suggestion of a $3 reduction in pig iron. They maintain that they are well sold up, say as to 90 per cent of their prospective make to July 1, and on contracts that can be enforced. Many steel contracts, on the other hand, are in accordance with the trade practice subject merely to the desire of the buyer to specify under them.

Unfinished steel is reduced $4 a ton to $43.50 for billets, $47 for sheet bars and small billets and $46 for slabs, rods being left at $57. Reductions in finished steel, in dollars per net ton to cents per pound are: Plates, $5 to 3c.; shapes, $4 to 2.80c.; bars, $4 to 2.70c.; blue annealed sheets 10 gage, $7 to 3.90c.; black sheets, 28 gage, $6 to 4.70c.; galvanized sheets, 28 gage, $4 to 6.05c.; steel pipe, $6 to a card with 54 per cent basing discount. Wire products are not reduced. The schedule aims to take into account production costs in the different lines. The suggested reduction in pig iron is $3, which would make basic prices, f.o.b. furnace or f.o.b. basing point in certain cases, $30 for basic, $32.20 for bessemer and $31 for No. 2 foundry, 1.75 to 2.25 per cent silicon.

Pig Iron Prices

Apart from the argument that their product is already well sold up on firm contract, the blast furnaces probably feel that reduction should be avoided at this time because a general reduction would not promise a stable market to the same extent as would exist in steel, since the pig iron market would still have some abnormal alignments to smooth out. The control prices for the different districts do not bear the relations to each other that usually obtain. Birmingham is as high as Valley, Eastern Pennsylvania has a Pittsburgh basing, and so on. These relations will not continue indefinitely.

War orders are practically all canceled by this time, and requirements on behalf of shipbuilding and the railroads are on a reduced basis, in the case of shipbuilding because there is an accumulation of steel and in the case of the railroads because the matter of control and ownership of the railroads for the future is not determined, this preventing the carrying out of any definite policy. The demand for steel that accumulated during the period of delivery control is being worked out. In the case of sheets this is quite heavy, automobile builders and various metal working shops being ready and anxious for deliveries. In other lines there is some accumulation. No new demand is originating from ultimate consumers, particularly from investors. The need may exist for more factories, bridges and the like, but it is too soon for it to be expressed. Lighter and lighter operation of the steel industry as a whole is promised until regular investment buying becomes a factor. Steel production may drop to 80, 70 or possibly even 60 per cent of capacity in from one to three months.

Safety for Steel User Demanded

The revival of demand for steel on a broad scale commensurate with the capacity of the industry hinges chiefly upon the matter of stability and cost of investments. The investor in works of permanent construction must be assured of safety for his investment—no bolshevism—and of there being no saving by postponing action. The cost of producing steel is high and may remain nearly as high as now. The cost of putting steel into employment is still more abnormal, by reason of high costs of other construction material, of high wage rates and labor scarcity and of very indifferent performance by labor. For a full demand for steel to be expressed there is more need for reduction in the cost of consuming steel than for reduction in the cost of producing steel. Thus the steel producer has not the power to make conditions favorable to heavy production and consumption of steel, but must bide his time, meanwhile endeavoring to squeeze out of the contract business on books as much tonnage as possible and at as favorable prices as possible, putting his works in good shape and weeding out the worst slackers in the working forces.

Chemical Market

HEAVY CHEMICALS:—Conditions surrounding this market have developed into an exceptionally unsettled situation. Many of the buyers were seemingly of the impression that shortly after the armistice signing immediate resumption of peace conditions would set in, but this having not taken place has apparently created a very quiet market, whereby the trading that is passing is only for pressing needs, with no disposition on the part of buyers to purchase ahead, while also great anxiety is noticeable among dealers relative to the final condition, after the readjustment takes place, and which is now under way. However, during the interval many price changes are being effected, and almost in every instance having a downward tendency. Second hands, who are apparently anticipating further reductions, are selling below the manufacturers' prices.

Caustic Soda:—There has been a continued indifferent attitude on the part of buyers, and the market during the latter part of the week developed a rather weak position, with material from the warehouses declining from $3.90 to $3.80 per hundred pounds. The trade is looking forward to the day when steamer space will be more free, and many prominent authorities have this item noted for a large volume of foreign business. Second hands are offering the product over next year at price concessions, while producers' quotations are unchanged at $3.30 to $3.40 basis 60% works.

Soda Ash:—Demand for this product has been comparatively light, although factors are also looking forward with confidence to an improved export movement, but any opinion is more or less of a speculative nature owing to the uncertainty surrounding the freight situation. Bag material in New York was offered at from 2c. to 2¼c. per pound, while light ash in barrels was available from the warehouse at $2.40 and double bags from middle western shipping points were quoted at $2.40 to $2.50 per hundred pounds.

Bleaching Powder:—Trading of a minor character continues to feature this market, but producers are apparently in a position to maintain their prices, at the recent decline. The material in domestic drums was quoted at from 2c. to 2¼c. per pound, while that in export drums was held at 3½c. to 3¾c. per pound F.A.S.

Bichromate of Soda:—No material improvement can be traced in the consuming demand for this product. Fair quantities of the material was available in the resale market at from 17c. to 17½c. per pound, while first hands were quoting at from 17½c. to 18c. for goods from the warehouses.

Bichromate of Potash:—Trading in any appreciable quantity is not in evidence; however, stocks on the spot are adequate for the current call. Dealers continue to quote at from 38c. to 40c., according to quantity.

Hyposulphite of Soda:—The precipitated product, which is the most preferable, is none too free in supply, although consuming requirements are not strong and the situation on the whole is well met. Offerings of the product are made at 3½c. per pound, but some business has passed below this figure.

Bicarbonate of Soda:—Producers report a fairly active call for this material on contract, but the recent activity in the market for spot goods has eased up to a very noticeable extent, due to the fact that certain buyers who were taking considerable of the material from the market have bought up to their requirements. Barrel material is quoted at 3¼c. per pound, while that in kegs is held at 3½c. per pound.

Permanganate of Potash:—Second hands are keeping spot prices for this commodity rather unsettled, while first hands are reporting a rather steady market at $1.50 for the U.S.P. product. The technical grade is subject to no important call and is quoted at from $1.25 to $1.30.

Carbonate of Magnesia:—The market remains quietly firm, with no price changes noted, and trading is of a routine nature, with no interest otherwise noted. Standard brands in bags are offered at 12½c. to 14c. per pound, while the product in barrels is quoted at 16c. to 18c. per pound.

COAL TAR PRODUCTS:—The quietness that has been in evidence for some time continues and has had its effect on the market, with many of the items subject to a decline. Buyers are apparently of the opinion that further reductions in prices will develop, and purchasing is merely for immediate needs. This condition, in addition to the shading of prices, featured the market during the interval. Among the crudes, benzol prices were firmly maintained by the producers, while phenol has been subject to a sharp decline, with frequent cheap offerings appearing in the resale market. Toluol, which is now in liberal supply on the spot, has also gone down with a swoop. There are many of the intermediates which are still in scant supply, but owing to the seasonal dullness the situation on the whole is well met.

Benzol:—Prices for this commodity are firmly maintained despite the quietness that is prevailing, with no indication of any material changes developing at the moment. The present demand is of a routine nature, with no other interest noted.

Phenol:—An unsettled condition has developed in this market due to the extensive stocks reported to be on hand in the various directions, and producers have reduced their prices 10c., while offerings in the resale market are frequently heard at from 5c. to 10c. below this figure.

Metatoluolenediamine:—The commodity is another of the items that has been affected through the recent decline in toluol and factors in this line are now offering at from 10c. to 15c. below the recent quotations, with very little interest shown on the part of buyers, who seemingly are anticipating a further decline.

Diethylaniline:—The slack that has also appeared in this market has brought about an easier situation so far as stocks are concerned and prices in some instances have declined from 25c. to 50c., while other directions are not disposed to alter their recent quotations.

Benzidine:—Local interest in the product is without special feature and the sulphate seems to be entirely neglected, while the only interest noted at the moment is for the base product for export purposes. Stocks on the whole are in sufficient quantities to take care of additional business, but prices are quotably unchanged.

Aniline Salt:—This item of the coal tar products has been subject to no important call during the past two weeks, with anxious weak holders playing havoc with the market on several occasions. Producers, however, have not changed their quotations since the recent decline.

Benzoic Acid:—Under liberal offerings and the continued quiet demand the market has apparently developed a rather weak position and the trading that is passing is transacted at some low levels, although producers have not materially changed their prices.

Alpha Naphthol:—The market remains quietly firm, with the demand for consumers' use being of a routine nature and prices for both the refined and crude grades being firmly maintained by producers.

Metaphenylenediamine:—The item is neither in pronounced supply nor demand and prices are fairly steady.

Metanitraniline:—Stocks of this product are adequate for the current call and dealers in the material are experiencing no difficulty in maintaining the present prices.

Dimethylaniline:—The consuming demand has eased up to a very noticeable extent and stocks therefore have accumulated, with the result that in some quarters price concessions were made, but this situation has originated no activity on the part of buyers.

Dinitrophenol:—There are now ample supplies on the spot of this product, which has been in scant supply for a long period, but quoted prices are subject to no material change.

Metanitroparatoluidin:—No important stocks of this product are noted and the spot situation is more or less nominal, with prices remaining firm.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET DEC. 27, 1918

Acetic anhydride	lb.	1.60 —	1.85
Acetone	lb.	.25½ —	.25½
Acid, acetic, 28 per cent	cwt.	5.96 —	6.11
Acetic, 56 per cent	cwt.	10.76 —	10.87
Acetic, glacial, 99½ per cent, carboys	cwt.	19.00 —	19.20
Boric, crystals	lb.	.13½ —	.15
Citric, crystals	lb.	1.18 —	1.25
Hydrochloric, C. P	lb.	Nominal	
Hydrofluoric, 30 per cent, in barrels	lb.	.08 —	.08½
Lactic, 44 per cent	lb.	.15 —	.16
Lactic, 22 per cent	lb.	.06 —	.07
Molybdic, C. P	lb.	6.90 —	7.40
Nitric, 36 deg	lb.	Nominal	
Nitric, 42 deg	lb.	.08½ —	.10
Oxalic, crystals	lb.	.38 —	.40
Phosphoric, 47-50 per cent paste	lb.	.07½ —	.10
Phosphoric, ref. 50 per cent	lb.	.35 —	.40
Picric	lb.	.75 —	.85
Pyrogallic, resublimed	lb.	3.25 —	3.50
Sulphuric, 60 deg	ton	16.00 —	.....
Sulphuric, 66 deg	ton	25.00 —	.....
Sulphuric, oleum (Fuming), tank cars	ton	60.00 —	65.00
Tannic, U. S. P., bulk	lb.	1.40 —	1.50
Tartaric, crystals	lb.	.86 —	.95
Tungstic, per lb. of W	lb.	1.70 —	1.75
Alcohol, sugar cane, 188 proof	gal.	4.91 —	.....
Alcohol, wood, 95 per cent	gal.	.91½ —	.92
Alcohol, denatured, 180 proof	gal.	.68 —	.69
Alum, ammonia lump	lb.	.07½ —	.08½
Alum, chrome ammonium	lb.	.18 —	.19
Alum, chrome potassium	lb.	.20 —	.22
Alum, chrome sodium	lb.	.12½ —	.13
Alum, potash lump	lb.	.09½ —	.10
Aluminium sulphate, technical	lb.	.02½ —	.02½
Aluminium sulphate, iron free	lb.	.04½ —	.04½
Ammonia aqua, 26 deg., carboys	lb.	.08½ —	.09
Ammonia, anhydrous	lb.	Nominal	
Ammonium carbonate	lb.	12 —	.13
Ammonium nitrate	lb.	(Fixed Price)	.15
Ammonium, sulphate domestic	gal.	.07½ —	.08
Amyl acetate	lb.	5.30 —	5.35
Arsenic, white	lb.	.09½ —	.13
Arsenic, red	ton	.65 —	.70
Barium carbonate, 99 per cent	ton	80.00 —	90.00
Barium carbonate, 97-98 per cent	ton	65.00 —	67.00
Barium chloride	ton	70.00 —	80.00
Barium sulphate (Blanc Fixe, Dry)	lb.	.04½ —	.05
Barium nitrate	lb.	.12 —	.14
Barium peroxide, basis 70 per cent	lb.	.30 —	.32
Bleaching powder, 35 per cent chlorine	lb.	.02 —	.03½
Borax, crystals, sacks	lb.	.08½ —	.08¾
Brimstone, crude	ton	65.00 —	70.00
Bromine, technical	lb.	.75 —	.....
Calcium, acetate, crude	lb.	.04 —	.05
Calcium, carbide	lb.	.15 —	.17
Calcium chloride, 70-75 per cent, fused, lump	ton	22.00 —	24.00
Calcium chloride, 70-75 per cent, fused,	lb.	1.50 —	1.70
Calcium peroxide	lb.	.22 —	.23
Calcium phosphate	lb.	.09 —	.09½
Calcium sulphate, 98-99 per cent	lb.	.08 —	.09
Carbon bisulphide	lb.	.16 —	.18
Carbon tetrachloride, drums	lb.	1.10 —	1.50
Carbonyl chloride (phosgene)	lb.	.67 —	.72
Caustic potash, 88-92 per cent	100 lb.	4.15 —	4.25
Caustic soda, 76 per cent	lb.	.....	.07½
Chlorine, liquid	lb.	1.60 —	1.65
Cobalt oxide	lb.	.02½ —	.02½
Copperas	lb.	.30 —	.31
Copper carbonate	lb.	.75 —	.78
Copper cyanide	lb.	.09½ —	.09½
Copper sulphate, 99 per cent, large crystals	lb.	.65 —	.70
Cream of tartar, crystals	100 lb.	3.10 —	3.40
Epsom salt, bags, U.S.P	lb.	.16½ —	.....
Formaldehyde, 40 per cent	lb.	.02½ —	.03
Glauber's salt	lb.	.63 —	.65
Glycerine, bulk, C.P	lb.	4.25 —	4.30
Iodine, resublimed	lb.	.06 —	.08
Iron oxide	lb.	.17 —	.17½
Lead acetate, white crystals	lb.	.15 —	.18
Lead arsenate (Paste)	lb.	Nominal	
Lead nitrate	lb.	.12 —	.14
Litharge, American	lb.	1.50 —	2.05
Lithium, carbonate	lb.	.16 —	.17
Magnesium carbonate, technical	lb.	.14 —	.15
Nickel salt, single	lb.	.12 —	.13
Nickel salt, double	lb.	1.10 —	1.50
Phosgene (see Carbonyl chloride)	lb.	1.17 —	1.20
Phosphorus, red	lb.	1.20 —	1.25
Phosphorus, yellow	lb.	.40 —	.45
Potassium bichromate	lb.	1.25 —	1.26
Potassium bromide granular	lb.	.38 —	.40
Potassium carbonate calcined, 85-90 per cent	lb.	.38 —	.40
Potassium chlorate, crystals	lb.	.60 —	.70
Potassium cyanide, 98-99 per cent	lb.	3.75 —	3.80
Potassium iodide	ton	300.00 —	350.00
Potassium muriate, 80-85 p. c. basis of 80 p. c.	lb.	.27 —	31
Potassium nitrate	lb.	1 50 —	1 75
Potassium permanganate, U. S. P.	lb.	2 30 —	2.50
Potassium prussiate, red	lb.	.88 —	.95
Potassium prussiate, yellow	ton	Nominal	
Potassium sulphate, 90-95 p. c. basis 90 p. c.	lb.	.47 —	.48
Rochelle salts	lb.	.21 —	.22
Salammoniac, gray gran	lb.	.18 —	.20
Salammoniac, white gran	100 lb.	1 40 —	1.65
Sal soda	ton	18 00 —	20 00
Salt cake	oz.	.....	.....
Silver cyanide, based on market price of silver	oz.	.63½ —	.64
Silver nitrate	lb.	2 05 —	07
Soda ash, 58 per cent, light, flat (bags)	100 lb.	3 40 —	3 60
Soda ash, 58 per cent, dense, flat	100 lb.	Nominal	
Sodium acetate	lb.	.03½ —	.03½
Sodium bicarbonate, domestic	lb.	.....	.....
Sodium bicarbonate, English	lb.	.18½ —	.20
Sodium bichromate	lb.	.12 —	.14
Sodium bisulphite, powd	lb.	.25 —	.25½
Sodium chlorate	lb.	.30 —	.35
Sodium cyanide	lb.	.17 —	.18
Sodium fluoride, commercial	lb.	3 10 —	3.50
Sodium hyposulphite	lb.	2.50 —	.....
Sodium molybdate, per lb. of Mo	100 lb.	4.12 —	5.00
Sodium nitrate, 95 per cent	lb.	.27 —	.30
Sodium nitrite	lb.	.35 —	.45
Sodium peroxide	lb.	.04 —	.04½
Sodium phosphate	lb.	.38 —	.39
Sodium prussiate, yellow	lb.	.03 —	.04
Sodium silicate, liquid (60 deg.)	lb.	.02 —	.03
Sodium sulphide, 30 per cent, crystals	lb.	.05 —	.06
Sodium sulphide, 60 per cent, fused	100 lb.	.05½ —	.06
Sodium sulphite	lb.	.25 —	.30
Strontium nitrate	lb.	.07½ —	.09
Sulphur chloride, druma	lb.	.15 —	.40
Sulphur dioxide, liquid, in cylinders	100 lb.	4.35 —	4.50
Sulphur, flowers, sublimed	100 lb.	3.70 —	3.85
Sulphur, roll	ton	65.00 —	70.00
Sulphur, crude	lb.	.28 —	.29
Tin bichloride, 50 deg	lb.	Nominal	
Tin oxide	lb.	.18 —	.20
Zinc carbonate	lb.	.15 —	.15½
Zinc chloride	lb.	Nominal	
Zinc cyanide	lb.	.13½ —	.14
Zinc dust, 350 mesh	lb.	.12 —	.12½
Zinc oxide, American process XX	lb.	.04½ —	.06½
Zinc sulphate			

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.22 —	.27
Benzol, 90 per cent	gal.	.25 —	.....
Toluol, in tank cars	gal.	.25 —	.....
Toluol, in druma	gal.	.30 —	.35
Xylol, pure, water white	gal.	.45 —	.55
Solvent naphtha, water white	gal.	.18 —	.25
Solvent naphtha, crude, heavy	gal.	.12 —	.15
Creosote oil, 25 per cent	gal.	.45 —	.55
Dip oil, 20 per cent	gal.	.40 —	.45
Pitch, varinus grades	ton	8.00 —	20.00
Carbolic acid, crude, 95-97 per cent	lb.	1.05 —	1.10
Carbolic acid, crude, 50 per cent	lb.	.60 —	.65
Carbolic acid, crude, 25 per cent	lb.	.35 —	.38
Creaol, U. S. P	lb.	.18 —	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00 —	1.10
Alpha naphthol, refined	lb.	1.50 —	1.60
Alpha naphthylamine	lb.	.55 —	.60
Aniline oil, druma extra	lb.	.27 —	.30
Aniline salts	lb.	42 —	.43
Anthracene, 80 per cent	lb.	Nominal	
Benzaldehyde (f.f.c.)	lb.	4.25 —	4.50
Benzidine, base	lb.	1.65 —	1.75
Benzidine, sulphate	lb.	1.35 —	1.40
Benzoic acid, U. S. P	lb.	2.25 —	2.50
Benzoate of Soda, U. S. P	lb.	2.15 —	2.25
Benzyl chloride	lb.	2 45 —	2.50
Beta naphthol benzoate	lb.	10.00 —	12.00
Beta naphthol, sublimed	lb.	.75 —	.85
Beta naphthylamine, sublimed	lb.	2.65 —	.....
Dichlor benzol	lb.	.15 —	.20
Diethylaniline	lb.	3 50 —	4.00
Dinitro benzol	lb.	.36 —	.38
Dinitrochlorbenzol	lb.	.39 —	.41
Dinitronaphthaline	lb.	.55 —	.60
Dinitrotoluol	lb.	.65 —	.75
Dinitrophenol	lb.	.49 —	.50
Dimethylaniline	lb.	.70 —	.73
Diphenylamine	lb.	1 00 —	1.10
H-acid	lb.	3.00 —	3.25
Metaphenylenediamine	lb.	1.85 —	2.05
Monochlorbenzol	lb.	.16 —	.19
Naphthalene, flake	lb.	.09 —	.....
Naphthalene, balls	lb.	.11 —	.12½
Naphtionic acid, crude	lb.	1.20 —	1 30
Naphthylamin-di-sulphonic acid	lb.	1.00 —	1.10
Nitro naphthaline	lb.	.45 —	.50
Nitro toluol	lb.	.55 —	.60
Ortho-amidophenol	lb.	6 00 —	7.00
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-toluidine	lb.	1 00 —	1.10
Ortho-nitro-toluol	lb.	.75 —	.85
Para-amidophenol, base	lb.	4 50 —	.....
Para-amidophenol, H. C. L	lb.	4 25 —	5 00
Para-dichlor-benzol	lb.	.15 —	.20
Paranitraniline	lb.	1 75 —	1 85
Para-nitro-toluol	lb.	1 50 —	1.60
Paraphenylenediamine	lb.	3 50 —	4.00
Para toluidine	lb.	2 25 —	2.50
Phthalic acid anhydride	lb.	3 50 —	3 75
Phenol, U. S. P	lb.	.30 —	.40
Resorcin, technical	lb.	4 50 —	5 00
Resorcin, pure	lb.	7 00 —	8.00
Salicylic acid U. S. P	lb.	.77 —	.85
Salol	lb.	1 50 —	2.00
Sulphanilic acid, crude	lb.	.31 —	.33
Toluidine	lb.	2 50 —	3.00
Toluidine-mixture	lb.	1 00 —	.....

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	4 00 —	.....
Corning, Ohio	bbl.	2 85 —	.....
Somerset, Ky	bbl.	2 60 —	.....
Wooster, Ohio	bbl.	2 68 —	.....
Indiana	bbl.	2 28 —	.....
Illinois	bbl.	2 42 —	.....
Oklahoma and Kansas	bbl.	2 25 —	.....
Caddo, La., light	bbl.	2 25 —	.....
Corsicana, Tex., light	bbl.	2 25 —	.....
California	bbl.	1 24 —	1.57
Gulf Coast	bbl.	1 35 —	.....
Mexican	bbl.	1 90 —	.....
Fuel Oil			
New York	gal.	.15 —	.....
Philadelphia	gal.	.10½ —	.....
Baltimore	gal.	.07½ —	.15
Pittsburgh	gal.	.07½ —	.10½
Texas	bbl.	1.85 —	2.35
Los Angeles	bbl.	1.65 —	.....

Gasoline (Wholesale)				
New York, motor	gal.	.24½	—	....
Gas machine	gal.	.41½	—	....
72-76 degrees	gal.	.33½	—	.39½
70-72 degrees	gal.	.32	—	.37½
67-70 degrees	gal.	.30½	—	.36½
Pittsburgh, motor	gal.	.25½	—	....
Chicago, motor	gal.	.22½	—	.23
Oklahoma, motor	gal.	.21½	—	....
San Francisco, motor	gal.	.20½	—	....

Paraffine Waxes

Crude, 103 to 105 deg. m.pt	lb.	08½	—	.09
Crude, 118 to 120 deg. m.pt	lb.	.09½	—	.10
Crude, 124 to 126 deg. m.pt	lb.	.10	—	....
Refined, 120 deg. m.pt	lb.	.13½	—	....
Refined, 128 deg. m.pt	lb.	.14	—	....
Refined, 135 deg. m.pt	lb.	.16	—	.16½
Ozokerite, brown	lb.	.75	—	.80
Ozokerite, green	lb.	.85	—	.90

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.24	—	.25
Cylinder, light	gal.	.45	—	.50
Cylinder, dark	gal.	.39	—	.43
Paraffine, high viscosity	gal.	.40	—	.41
Paraffine, 0.903 sp. gr.	gal.	.36	—	.38
Paraffine, 0.885 sp. gr.	gal.	.26	—	.28

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f. o. b. Florida	gal.	.44	—	....
Pine oil, steam-distilled, sp. gr. 0.925-0.940	gal.	.58	—	.60
Pine oil, destructively distilled	gal.	.58	—	.60
Pine-tar oil, sp. gr. 1.02-1.035	gal.	.35	—	....
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.42	—	....
Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f.o.b. works	gal.	.37	—	....
Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.28	—	....
Pine-tar oil, ref., thin, sp. gr. 1.060-1.080	gal.	.32	—	....
Turpentine, crude, sp. gr. 0.870-0.900	gal.	.45	—	....
Hardwood oil, f.o.b. Michigan, sp.gr. 0.960-0.990	gal.	.23	—	....
Hardwood oil, f.o.b. Michigan, sp.gr. 1.06-1.08	gal.	.23	—	....
Wood creosote, ref., f.o.b. Florida	gal.	.31	—	....

Naval Stores

Rosin A-E barrel	280 lb.	14.40	—	14.75
Rosin F-I	280 lb.	14.75	—	15.00
Rosin K-N	280 lb.	16.75	—	17.75
Rosin WG-W	280 lb.	17.85	—	18.25
Spirits of turpentine	gal.	.71	—	....
Wood turpentine, steam distilled	gal.	.62	—	.65
Wood turpentine, destructively distilled	gal.	.58	—	....
Pitch	bbl. 200 lb.	8.00	—	....
Tar, kiln dried	280 lb.	13.00	—	13.50
Retort tar	280 lb.	14.00	—	14.50
Rosin oil, first run	gal.	.80	—	....
Second run	gal.	.83	—	....
Third run	gal.	.88	—	....
Fourth run	gal.	.98	—	....

Vegetable Oils

Castor oil	lb.	.33	—	.34
China wood oil	lb.	.25	—	.28
Cocoanut oil	lb.	.16	—	.21
Corn oil	lb.	.18	—	....
Cottonseed oil, crude	lb.	.17½	—	.22
Linseed oil, raw, cars	gal.	1.81	—	1.86
Palm	lb.	.17½	—	.18½
Peanut oil, crude	lb.	.18	—	.22
Soya bean oil, Manchuria	lb.	.17	—	.18½

Glues

Extra white	lb.	.36	—	.45
Cabinet	lb.	.31	—	.40
Brown foot stock	lb.	.18	—	.22
Fish glue, 50-gal. barrels	gal.	1.00	—	1.80

Miscellaneous Materials

		Nominal		
Barytes, floated, white, foreign	ton	33.00	—	36.00
Barytes, floated, white, domestic	ton	.63	—	.65
Beeswax, white, pure	lb.	.43	—	.48
Beeswax, unbleached	lb.	.05½	—	....
Blanc fixe	lb.	.17½	—	.30
Casein	lb.	.07½	—	.25
Ceylon graphite	lb.	.04½	—	.06
Chalk, light, precipitated, English	lb.	20.00	—	40.00
China clay, imported, lump	ton	15.00	—	22.50
China clay, domestic, lump	ton	8.00	—	12.00
Feldspar	ton	28.00	—	40.00
Fluorspar, gravel, f.o.b. mines	ton	90.00	—	....
Fluorspar, washed, powdered	100 lb.	1.50	—	2.00
Fuller's earth, powdered	lb.	.26	—	.27
Japan wax	ton	60.00	—	75.00
Mexican graphite	ton	.10	—	.15
Madagascar graphite	lb.	.72	—	.80
Orange shellac	lb.	.04	—	.08
Pumice stone	lb.	.11½	—	.11½
Red lead, dry, carloads	100 lb.	15.00	—	25.00
Soapstone	ton	.13	—	.14
Stearic acid, 120 deg. m.pt	lb.	.18	—	.19
Stearic acid, 140 deg. m.pt	lb.	20.00	—	40.00
Talc, American, white	ton	.09¼	—	.10½
White lead, dry	lb.			

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	175.00	—	....
Chrome cement	net ton	75.00	—	....
Clay brick, first quality fireclay	per 1000	50.00	—	55.00
Clay brick, second quality	per 1000	35.00	—	40.00
Magnesite, raw	ton	30.00	—	35.00
Magnesite, calcined, powdered	ton	50.00	—	65.00
Magnesite, dead burned	net ton	50.00	—	60.00
Magnesia brick, 9x4½x2½	net ton	110.00	—	125.00
Silica brick	per 1000	50.00	—	60.00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent, carloads, f. o. b. Niagara Falls, N. Y.	ton	200.00	—	250.00
Ferrocerium	lb.	15.00	—	30.00
Ferrochromium, per lb. of Cr	lb.	.30	—	.40
Ferromanganese, domestic, 70 per cent basis	ton	240.00	—	....
Ferromanganese, English	ton	325.00	—	....
Spiegeleisen (16-18%)	ton	70.00	—	....
Ferromolybdenum, per lb. of Mo	lb.	3.50	—	4.50
Ferrosilicon, 75 per cent, f.o.b. N. Y.	ton	....	—	....
Ferrosilicon, 50 per cent, contract	ton	153.00	—	160.00
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	2.35	—	2.40
Ferrouranium, f.o.b. works, per lb. of U	lb.	7.50	—	....
Ferrovanadium, f.o.b. works	lb.	....	—	....

Ores and Semi-finished Products

Chrome ore, 45 per cent minimum, f.o.b. Cal. per unit	ton	1.50	—	1.55
Chrome ore, 43 per cent and over, New York, per unit	ton	1.40	—	....
Coke	ton	6.00	—	7.00
Manganese ore, 48 per cent and over, per unit	ton	1.20	—	....
Manganese ore, chemical	ton	80.00	—	100.00
Molybdenite, per lb. of MoS_2	lb.	1.25	—	1.50
Tungsten, Scheelite, per unit of WO_3	ton	25.50	—	....
Tungsten, Wolframite, per unit of WO_3	ton	23.00	—	....
Uranium oxide, 96%	lb.	3.25	—	3.60
Vanadium pentoxide, 99%	lb.	10.50	—	....
Pyrites, foreign	unit	.17	—	....
Pyrites, domestic	unit	.28	—	.30½

Plant Supplies

BUILDING MATERIALS

Common clay bricks	M	13.00	—	14.00
Hollow tile, 4x12x12	M	60.00	—	....
Hollow tile, 12x12x12	M	170.00	—	....
Lime	ton	16.50	—	....
Portland cement	bbl.	2.59	—	....
Single glass (82-lb.), 10x26-16x24		21.00	—	27.00
Double glass (164 lb.), 10x26-16x29		31.00	—	39.00
Yellow pine lumber	M	39.00	—	45.00
Fir lumber	M	38.00	—	53.00
Hemlock	M	24.50	—	40.00
Tarred felt (14-lb. sq.)	ton	68.00	—	....
Roofing pitch	ton	27.00	—	....
Asphalt coated roofing (35-55-lb.sq.)	sq.	1.60	—	2.45
Slate surfaced asphalt shingles	sq.	5.25	—	5.50
Corrugated galvanized iron	ton	109.00	—	127.00
Putty	100 lb.	6.25	—	....
Red oxide (Ppte. Copperas)	100 lb.	15.00	—	20.00
Native red oxide	100 lb.	3.25	—	8.00
Red metallic paint	100 lb.	1.20	—	1.50
White lead in oil	100 lb.	11.84	—	14.00
Red lead in oil	100 lb.	12.28	—	14.50
Zinc oxide (dry)	100 lb.	13.00	—	14.50
Zinc oxide—leaded	100 lb.	9.00	—	10.00
Yellow ochre	100 lb.	1.50	—	10.00
Ultra marine blue	100 lb.	14.00	—	50.00
Prussian blue	100 lb.	135.00	—	150.00
Chrome green	100 lb.	40.00	—	70.00
Paris green	100 lb.	43.00	—	49.00
Mineral black	100 lb.	1.75	—	2.25
Powdered bone black	100 lb.	5.50	—	12.00
Lampblack	100 lb.	15.00	—	45.00
Gas carbon	100 lb.	16.00	—	25.00
Mexican petrolcum pitch	100 lb.	1.00	—	2.00
Gilsonite	100 lb.	2.00	—	2.50
Coal tar pitch	100 lb.	.60	—	1.25

STRUCTURAL IRON

Blue annealed sheet iron	ton	84.00	—	89.00
Black sheet iron	ton	96.00	—	104.00
Galvanized iron	ton	105.00	—	135.00
Tern plate, 8-lb. coating	ton	150.00	—	....
Tern plate, 15-lb. coating	ton	177.50	—	....
Tern plate, 25-lb. coating	ton	200.00	—	....
Tern plate, 40-lb. coating	ton	240.00	—	....
Tin plate, prime	ton	155.00	—	....
Tank plates	ton	65.00	—	65.00
Beams, channels, angles, T's, Z's	ton	60.00	—	70.00
Rivets	ton	88.00	—	92.00
Steel pipe, ¾ to 3-inch	ton	51.00	—	....
Bar iron and steel	ton	60.00	—	70.00
Chain (1 inch proof coil)	ton	150.00	—	....
Nails, bolts, nuts, washers	ton	70.00	—	80.00
Tool steels, special alloys	ton	300.00	—	500.00
Bessemer pig iron	ton	36.60	—	....
Bessemer steel	ton	47.50	—	....
No. 2 foundry	ton	37.00	—	....
Steel billets (4 x 4)	ton	47.50	—	....

POWER HOUSE SUPPLIES

Steam packing, rubber duck	lb.	.99	—	1.10
Asbestos, high pressure	lb.	1.76	—	....
Asbestos, wired	lb.	1.30	—	....
Asbestos, graphited braid	lb.	1.21	—	....
Asbestos, wick	lb.	.75	—	....
Rubber, sheet	lb.	.66	—	....
Cup grease	lb.	.07	—	....
Transmission grease	lb.	.07	—	....
Axle grease	lb.	.04½	—	....
Gear grease	lb.	.04½	—	....
Cotton waste	lb.	.08½	—	.11
Hose, underwriters, 2½ in.	ft.	.75	—	....
Hose, air, ¾ in.	ft.	.50	—	.60

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Alabama

ANNISTON—The Woodstock Iron & Steel Corporation will rebuild its sintering plant used for desulphurizing iron ores, recently destroyed by fire entailing a loss of $100,000.

Arizona

KINGMAN—The Catherine Mines will rebuild its mill at Pyramid, near here, and plans to renew operations on a larger scale.

MAYER—The Arizona Binghampton Copper Co. recently increased its capital stock to provide for extensions. Plans include the construction of a new addition to its flotation mill and the sinking of a new three-compartment shaft 1200 ft. It is understood that the company is planning for the erection of an aerial tram to the Humboldt smelter, about five miles.

WINKLEMAN—The Lavelle Gold Mining Co. will build a mill building, a 12 x 15 ft. dodge crusher, 50-ton Quenner dry crusher, amalgamation plates, four Wilfley tables and is in the market for crushers, plates, tables and accessories for second unit which will be built in July, 1919. Estimated cost, $60,000. A. Parker, 315 North 2nd St., Phoenix, superintendent.

California

CORONA—D. C. Crookshank, 322 East Holt St., will soon receive bids for the construction of a two-story, 80 x 88 ft. acid house for the Exchange By-Products Co., Corona. R. H. Orr, 1251 Van Nuys Bldg., Los Angeles, architect.

CORONA—The Exchange By-Products Co. has awarded the contract for the construction of a two-story, 80 x 88 ft. acid house, to the Oresmer Manufacturing Co., Riverside. Estimated cost, $30,000.

LOS ANGELES—The Western Pipe & Steel Co., North Broadway, has acquired a tract consisting of 130 lots in the Hay District, Vernon, near here, and will build extensions for the manufacture of riveted steel, iron and steel pipe, oil well castings, tanks, etc.

Colorado

CRIPPLE CREEK—The Lincoln Mines & Reduction Co. will build a new concentration plant at its manganese properties.

DURANGO—Bulkeley Wells and associates will build a new mill having a daily capacity of 200 tons in connection with the development of large alunite-potash deposits on Calico Peak.

PITKIN—The Pennsylvania Molybdenum Mines Co. will build a new mill at its Bon Ton mine.

Connecticut

NEW LONDON—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of a laboratory building, to T. A. Cassidy, Fitchburg, Mass. Estimated cost, $17,800.

Delaware

NEW CASTLE—The American Manganese Steel Co. will build a one story, 60 x 60 ft. addition to its core oven works. Estimated cost, $18,000.

District of Columbia

WASHINGTON—The Bureau of Yards & Docks, Navy Department, has awarded the contract for the construction of a laboratory building here, to the Boyle-Robertson Construction Co., Evans Bldg. Noted Nov. 30.

Florida

KEY WEST—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will soon award the contract for the construction of a photo-laboratory here. Estimated cost, $7000. Noted Dec. 15.

OKEELANTA — The Okeelanta Stock Farms Packing & Canning Co., 212 New Tatum Bldg., Miami, will build a dehydrating and canning plant in connection with its hog farm here.

Georgia

GRIFFIN—The Georgia Cotton Mills will enlarge its bleachery and will install kier, one set of dry cans, mangle, switcher and calender.

Idaho

KELLOGG—The Mullan Milling Co. will install fine crushing and flotation machinery and equipment in the new 150-ton mill recently completed.

WALLACE—The Spokane Metals Recovery Co., operating at Nine Mile, near here, will rebuild its plant recently destroyed by fire, entailing a loss of over $22,000. Plans include the installation of a ball mine and other equipment.

Illinois

CHICAGO—John F. Jelke Co., 759 South Washtenaw Ave., will build an addition to its butterine factory.

CHICAGO—R. J. Kittredge & Co., 812 Sulphur St., has purchased a site on West 47th St., and Whipple Ave., and will build a large plant for the manufacture of labels and wrappers. The first unit is estimated to cost $200,000.

CHICAGO—Wilson & Co., 41st St. and Ashland Ave., has awarded the contract for the construction of a 3 story, 20 x 34 ft. fertilizer, dryer and storage building, to J. B. Mullen, 1128 South Michigan Ave. Estimated cost, $65,000. Noted Oct. 15.

MAYWOOD—The Sanitary District, 900 South Michigan Ave., Chicago, will build a one and two story treating plant, to include drying plant, pumping station, etc. Total estimated cost, $800,000. E. L. Barrett, 900 South Michigan Ave., Chicago, architect.

Indiana

HARTFORD CITY—The Ft. Wayne Corrugated Paper Co., Murray and Barr St., Ft. Wayne, will build a two story addition to its factory here. D. S. Griffith, owner.

Iowa

CLARINDA—The city has had plans prepared for the construction of a mechanical filtration plant to purify the water obtained from the Nodaway River.

KEOKUK—The Gas Tank Recharging Co. will build a plant here for the manufacture of calcium carbide. Estimated cost, $500,000.

Kentucky

MARION—John Summers and associates will install a jig mill on a mining tract here and is in the market for equipment for same.

PADUCAH—The Union Mining Co., recently incorporated with a capital of $25,000, will develop about 140 acres of fluorspar and lead properties in the Paducah Section. Plans include the installation of new lead mining and fluorspar machinery. B. F. Weatzel, Shawnee Parkway and Chestnut St., Louisville, president.

Maryland

BALTIMORE—The Baugh Chemical Co., foot Clinton St., has awarded the contract for rebuilding its nitrate ovens, to C. L. Stockhausen, Marine Bank Building. Estimated cost, $20,000.

ELKTON—The Scott Fertilizer Co. will rebuild its plant recently destroyed by fire entailing a loss of $250,000.

SPARROW'S POINT—The Bethlehem Steel Co. has awarded the contract for the construction of a one story, 73 x 1070 ft. steel plate mill, to Deverill. Spencer & Co., 514 Garrett Building, Baltimore. Estimated cost between $150,000 and $200,000.

Massachusetts

BOSTON—The Air Reduction Co., 120 Broadway, New York City, N. Y., has awarded the contract for the construction of five buildings of the modified Austin No. 1 type, to the Austin Co., 16112 Euclid Ave., Cleveland, Ohio. Estimated cost, $40,000.

BOSTON—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will build a galvanizing plant here. Estimated cost, $50,000. C. W. Parks, chief.

CAMBRIDGE—Lever Bros. Co., 176 Broadway, has awarded the contract for the construction of a 5-story, 75 x 170 ft. addition to its factory for the manufacture of soap and glycerine, to Stone & Webster, 147 Milk St., Boston. Estimated cost, $500,000.

Michigan

DETROIT—Frederick Stearns & Co., Jefferson Ave., will build an eight story, 100 x 110 ft. drug manufacturing plant. Albert Kahn, Marquette Building, architect, preparing plans.

DETROIT—The Michigan Smelting & Refining Co., 1685 Joseph Campau Ave., has had plans prepared for the construction of a two story, 50 x 63 ft. cupola house, on Clay and Joseph Campau Aves. Albert Kahn, Marquette Building, architect.

PETOSKEY—The Petoskey Portland Cement Co. will build a cement plant. J. C. Buckley, 38 South Dearborn St., Chicago, Ill., engineer.

Minnesota

COLUMBIA HEIGHTS—The city will receive bids about June for the construction of a sewerage system. J. W. Shaffer, New York Life Building, Minneapolis, engineer.

ST. PAUL—O. B. Dailey & Son, 460 Selby Ave., will build a factory for the manufacture of gasoline substitute.

Missouri

ST. LOUIS—The Christian Brothers College, 5270 Page Ave., will install a chemical laboratory in the three story college which it will build on Clayton and Skinker Roads. Estimated cost, $200,000. Henry P. Hess, 4811 Cote Brilliant Ave., engineer.

ST. LOUIS—The Goodyear Metallic Rubber Shoe Co., 500 Bittner St., has awarded the contract for the construction of a two-story, 62 x 65 ft. vulcanizing building, to the Unit Construction Co., Title Guarantee Building. Estimated cost, $20,000.

ST. LOUIS—The St. Louis Hide & Tallow Co., 412 Talcott Ave., will rebuild its hide and tallow factory recently destroyed by an explosion, entailing a loss of $15,000.

New Jersey

BOUND BROOK—A. A. Marlow & Sons will build a chemical plant for the manufacture of liquid sulphur and chemicals and are in the market for sheet lead, lead pipes, boilers, compressors, sulphur burners, storage tanks and cylinders.

GLOUCESTER—The United States Government will build a fumigation plant and laundry here. Estimated cost, $26,000.

New Mexico

FT. HANCOCK—A. Kraft, operating a copper mine near here, will build a new 100-ton gravity concentrating and flotation mill at his plant.

New York

BROOKLYN—John Bene & Sons, 641 Dean St., will build a three story, 100 x 100 ft. chemical factory on Carlton Ave. near Fulton St. W. H. Gompert, 171 Madison Ave., New York City, engineer.

BUFFALO—The Buffalo Slag Co., Ellicott Square, will build a one story, 70 x 100 ft. crusher plant. Estimated cost, $12,000.

BUFFALO—W. P. Whitney, architect, 38 South Dearborn St., is preparing plans for the construction of a clay products plant in the suburbs near here. Plans include a one story, 10 x 12 x 700 ft. conveyor house; one story, 57 x 200 ft. warehouse, two small storage buildings, etc. Total estimated cost, $100,000. Owner's name withheld.

NEW YORK—F. L. Dowling, president of Manhattan Borough, has awarded the contract for furnishing and delivering liquid chlorine, to the Electro Bleach & Gas Co., 13 East 41st St., $6120; furnishing and delivering sulphate of copper, to J. Grieg, 39 Cortlandt St., $2901. Noted Dec. 15.

NIAGARA FALLS—The Acheson Graphite Co., Buffalo Ave., has awarded the contract for the construction of an addition to its plant, to the John W. Cowper Co., Fidelity Building, Buffalo. Estimated cost, $15,000.

North Carolina

MONROE—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will soon award the contract for the construction of a radio building here. Estimated cost, $250,000. Noted Dec. 15.

Ohio

AKRON—The Akron Soap Co., Cuyahoga St., will build a two story, 40 x 50 ft. disposal plant. Estimated cost, $5,000.

CANTON—The Republic Rubber Corporation, Albert St., Youngstown, will enlarge its plant here, to double its present capacity.

CLEVELAND—The Cleveland Furnace Co., 1314 Rockefeller Building, will build a one story, 52 x 62 ft. laboratory building, at 315 Clark Ave. Estimated cost, $6000. F. A. Dearborn, c/o owner, architect.

CLEVELAND—The Grasselli Chemical Co., Guardian Building, will build a one story, 82 x 204 ft. chemical plant, at 2625 Independence Rd. Estimated cost, $25,000.

CLEVELAND—The Ohio Bronze Powder Co., 1120 East 152nd St., has awarded the contract for the construction of a two story, 56 x 70 ft. factory, to the McMillan Co., 1794 East 55th St. Estimated cost, $18,000.

CLEVELAND—The United States Copper Co., Guardian Building, has awarded the contract for the construction of a brass and copper tube mill, to the Hunkin Conkey Construction Co., Century Bldg. Estimated cost, $100,000. Noted Dec. 15.

PARMA—(Cleveland P. O.)—Swift & Co., 3240 West 65th St., has awarded the contract for the construction of a two story, 50 x 75 ft. fertilizer factory, to the William Moore Co., 1278 West 4th St., Cleveland. Estimated cost, $25,000. Noted Oct. 31.

TOLEDO—The Paragon Refining Co., 2935 Front St., will improve its plant. Estimated cost, $50,000. J. C. Smith, secretary.

TOLEDO—The S. S. Royster Guano Co., Second National Bank Building, will build a sulphuric acid plant adjoining its present plant. Estimated cost, $500,000.

TOLEDO—The Standard Steel Tube Co., Fitchland Ave. and Detroit & Michigan Central R. R., has purchased a 40 acre site on South Detroit Ave., and will build a factory. Estimated cost, $500,000.

YOUNGSTOWN—The Industrial Gas & Chemical Co., recently incorporated with a capital of $250,000, will build a plant for the manufacture of welding gases, chemicals and dyestuffs.

Oklahoma

BLACKWELL—The Bartlesville Zinc Co. will enlarge its plant here.

LAWTON—The city has awarded the contract for the construction of a filtration plant, to the Selden-Breck Construction Co., Fullerton Building, St. Louis, Mo. Estimated cost, $157,000.

OKLAHOMA—The American Castor Oil Co., 600 Colcord Building, will build a tenton plant and install machinery in same. Estimated cost, $50,000. H. C. Leete, manager.

TULSA—The United States Compression Inner Tube Co., Daniels Building, will build a plant for the manufacture of rubber inner tubes for automobiles. C. R. Porter, secretary-treasurer.

Oregon

BAKER—Harry M. Quinn and C. G. Flanagan, Seattle, will install a flotation plant to replace the old 60-ton concentrator in the Highland Mine near here.

SUMMER LAKE—Jason C. Moore has leased Summer Lake from the State Land Board and will build a commercial reduction soda plant, for the manufacture of soda ash and potash, produced from the deposits of the lake. When production begins, royalty will be paid to the State Land Board at the rate of $.25 per ton for soda ash and $.50 for potash. Estimated cost, $90,000. E. W. Lazell, Railway Exchange Building, Portland, chemical engineer.

Pennsylvania

MARCUS HOOK—The National Aniline & Chemical Co. has awarded the contract for the construction of a 106 x 109 ft. modified Austin No. 9 building to the Austin Co., 16112 Euclid Ave., Cleveland, Ohio. Estimated cost, $32,000.

MT. HOLLY SPRINGS—The Mt. Holly Paper Co. has awarded the contract for the construction of a one story, 22 x 25 ft. addition to its paper factory, to H. A. Lackey, 520 North West St., Carlisle. Estimated cost, $5000.

PHILADELPHIA—The Kensington Hygeia Ice Co. has awarded the contract for the construction of a one story addition to the new cooling tower on Trenton Ave. and Huntingdon St., to the Cooling Tower Co., 15 John St., New York City, N. Y. Estimated cost, $5000.

PHILADELPHIA—The Samaritan Hospital, Ontario St., east of Broad St., will receive bids about June 1st, for the construction of a two-story, 25 x 81 ft. addition to its hospital, including a laboratory. Estimated cost, $12,000.

Rhode Island

PROVIDENCE—The Providence Steel & Iron Co., Kinsley Ave., has awarded the contract for the construction of a one-story fabricating plant, to Williams & Merchants, 87 Weybosset St. Estimated cost, $25,000.

South Dakota

HILL CITY—The American Tin & Tungsten Co. will remodel its plant near here and is in the market for a Telsmith gyratory crusher, Hardinge ball mill, Deister Plato slime table, Richards pulsator classifiers and electric furnace for smelting tin concentrates. Ralph S. Meyerin, superintendent.

Tennessee

BUTLER—The Elenor Manganese Co., recently incorporated with a capital of $15,000, will install the necessary equipment in the mine recently acquired from A. H. McQuenn to provide for an initial capacity of about 15 tons. R. B. Hayes, Masontown, Penn., president.

Texas

ABILENE—Charles Lindsey, 203 Fourth National Bank Building, Wichita, Kan., and others, have purchased a site here and will build an oil refinery. Estimated cost, $750,000.

COLLEGE STATION—The Board of Directors, Agricultural & Mechanical College of Texas, will receive bids until January 11 for the construction of a 65 x 130 ft. fireproof laboratory building for the Physics Department. Estimated cost, $60,000. W. Scott Dunne, Department of Architecture, architect.

FT. WORTH—Armour & Co., Union Stock Yards, Chicago, Ill., will build a six story, 220 x 300 ft. curing plant, having a 5,000,000 lb. capacity, in connection with the improvements which it plans to make to its packing plant. Total estimated cost, $500,000.

FT. WORTH—The Baltic Refining Co. has awarded the contract for the construction of a concrete and steel oil refinery, having a daily capacity of 500 barrels, to the Bryce Building Co., 909 Throckmorton Building. Equipment for refining petroleum into all finished products, including gasoline, kerosene, lubricating oils and wax will be installed in same. Estimated cost, $750,000.

FT. WORTH—The El Dorado Refining Co. will build a 5000 barrel refinery here. Estimated cost, $1,000,000.

FT. WORTH—The Evans Thwing Co. will build a refinery, having a capacity of 3500 barrels, on the site of the Tarrant County poor farm. Estimated cost, $600,000.

FT. WORTH—The Army and Navy Departments, Washington, D. C., will build a plant adjoining the Government experimental plant here for the manufacture of balloon gas. Estimated cost, $5,000,000.

FT. WORTH—The Sterling Oil & Refining Co., 511 Beacon Building, Wichita, Kan., will build an oil refinery here, to have an initial capacity of 5000 barrels. W. McGinley, president.

LA PORTE—Palmer Hughes, 912 Oxford St., and associates, have purchased a site near here and will build an oil refinery having a daily capacity of 600 barrels.

Virginia

LYNCHBURG—The Sanitax Dry Cleaning Co., Main and Chestnut St., has awarded the contract for the construction of a one story, 50 x 69 ft. dry cleaning plant to W. B. Snead & Co., 1321 Main St. Estimated cost, $15,000.

NORFOLK—The Norfolk Glass Manufacturing Co., 564 Church St., will build a plant near Berkley St. for the manufacture of glass specialties. Estimated cost, $200,000.

NORFOLK—The Virginia Fruit Juice Co., 4-12 Washington Ave., has awarded the contract for the construction of a two story, 44 x 65 ft. vinegar plant, to J. H. Pierce, Law Building.

PORTSMOUTH—The Southern Brass Works, National Bank of Portsmouth Building, has awarded the contract for the construction of a one story, 40 x 67 ft. extension to its plant, to John W. Hoffler, 504 5th St.

Washington

LOON LAKE—The Loon Lake Copper Co. will build a concentrating mill, to have a daily capacity of 100 tons. Estimated cost, $45,000. C. J. Stone, manager.

VALLEY—The Admiral Mining Co., Rookery Building, Spokane, has been authorized to issue $75,000 bonds, $50,000 of which will be used for concentrator to be installed here, if development work justifies same. J. Richard Brown, manager.

Wisconsin

JEFFERSON—The Board of Commissioners of Jefferson County will install a private water system and septic tanks in the two and three story, 100 x 150 ft. sanitarium which it will build. Estimated cost, $75,000. O. C. Uehling, First National Bank Building, Milwaukee, architect.

MILWAUKEE—The Milwaukee Gas Light Co., Milwaukee and Menominee St. will alter its gas plant. Estimated cost, $65,000.

MILWAUKEE—The Milwaukee Paper Box Co., 400 Florida St., will build a five story, 120 x 144 ft. manufacturing building and garage, on Pierce and Muskego Sts. Estimated cost, $225,000. Schnetzky & Son, 105 Wells St., architect.

RACINE—The Osborne Casting Co., Layard Ave., will build an addition to its core room, foundry and auxiliary building. Estimated cost, $20,000. C. G. Holmes, general superintendent.

Nova Scotia

HALIFAX—The Canada Metal Co., 37 Fraser Ave., Toronto, will build a plant here. Estimated cost, $50,000. W. G. Harris, preseident.

Ontario

BOSTON CREEK—The Miller Independence Mining Co. has increased its capital stock and will build an addition to its existing plant, and is in the market for crushing and grinding machinery and flotation mill and electrical equipment. George Miller, superintendent.

Quebec

CLARK CITY—The Gulf Pulp & Paper Co. will build a paper mill. Estimated cost, $10,000. T. Clark, superintendent.

Mexico

CUSIHUIRIACHIC—The Compania Minera del Mirasol will build a 200-ton concentrating mill. C. B. Clyne, Mills Bldg., El Paso, Texas, is preparing plans.

Manufacturers' Catalogs

THE JEFFREY MANUFACTURING CO., Columbus, Ohio, calls attention to a 72-page catalog, No. 244, on the Jeffrey bucket elevators in standard sizes. Forty pages are devoted to details of elevators selected out of numerous styles used in the handling of a wide range of materials in practically every industry of the country and known as Standard Elevators. A page is given to each Standard Elevator, which is illustrated, both in perspective and in line drawing, giving dimensions. There is also an illustration showing the chain and bucket used in that type of elevator, and at the bottom of each sheet is given a full list of all specifications applying to that particular elevator. This attractive catalog is ready for distribution to the trade.

THE INDEPENDENT FILTER PRESS CO., INC., Brooklyn, N. Y., has issued a catalog on the Indefilco filter press, and calls attention to patent No. 1,282,414 on an improved field plate, which is illustrated and described.

THE AMERICAN ZINC, LEAD & SMELTING CO., St. Louis, Mo., has just received from the press a 36-page booklet dealing with Azo zinc oxides, which will be sent upon request to any member of the trade.

Published SEMI-MONTHLY *on the* FIRST *and* FIFTEENTH *of each month*

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

McGRAW-HILL COMPANY, INC.
Tenth Avenue at 36th Street
NEW YORK

JAMES H. McGRAW, President
ARTHUR J. BALDWIN, Vice President E. J. MEHREN, Vice President
EDWARD CALDWELL, Treasurer JAMES H. McGRAW, JR., Secretary

TELEPHONE, 2840 Greeley. CABLE ADDRESS, Machinist, New York

WASHINGTON, 1410 H. St., N.W. SALT LAKE CITY, Newhouse Bldg.
CHICAGO, Old Colony Bldg. PHILADELPHIA, Real Estate Trust Bldg.
SAN FRANCISCO, Rialto Bldg. CLEVELAND, Leader-News Bldg.
LONDON, Hastings House, Norfolk St., Strand.

H. C. PARMELEE, Editor
ELLWOOD HENDRICK, Consulting Editor
ERNEST E. THUM, Western Editor
WALLACE SAVAGE, Assistant Editor

J. MALCOLM MUIR, Manager

Yearly Subscription price for United States, Mexico and United States dependencies, $3; all other countries, $4. Single Copy, 25c.

When change of address is ordered, the NEW and the OLD addresses must be given. Notice must be received at least 10 days before change takes place. No back copies for more than three months.

Copyright, McGraw-Hill Co., Inc., 1919. Entered as Second-Class Matter at the Post Office at New York, N. Y., under the Act of Congress, July 1, 1918.

Circulation of this issue 11,600 *copies*

CONTENTS *for* January 15, 1919

Volume 20, *Number* 2

EDITORIAL
The Outlook of the Optimist....49
Faith in Our Friends and Allies Across the Atlantic....50
Scrutable in the Penultimate....50
Capacities Well Aligned in the Iron Industry....51
READERS' VIEWS AND COMMENTS
Ferromanganese. By *A. R. Balcom*....52
Colloids in Flotation. By *Jackson A. Pearce*....52
An Analysis of Ferromanganese. By *L. R. Taylor*....53
That Missing Page From the Blue-Back Speller. By *R. A. Driscoll*....53
Rossiter W. Raymond....54
Western Chemical and Metallurgical Field....55
Industrial Efforts in France During the War. By *Georges Maoussa*....56
Phosphorus in Copper Alloys....58
Notes on Electrical Precipitators. By *Ernest Edgar Thum*....59
Ramsay Memorial Fund in America....64
Furnace Settings for Caustic Pots. By *Frank H. Nickle*....67
Platinum Economy in the Industrial Laboratory. By *E. C. Mueser*....69
Dyes and Other Coal-Tar Chemicals....70
An Example of Crystal Crushing....72
Electric Furnaces in the Steel Industry and Their Relation to the Central Station....73
Disposition of Munitions....76
Separation of Potash Salts. By *H. P. Bassett, Ph. D.*....76
Distillation of Coal at Low Temperature....78
Chrome Sands on the Pacific Coast. By *Justice F. Grugan*....79
Canadian Graphite Industry....81
Minor Occurrences of Mercury in Europe. By *Dr. Roland Sterner-Rainer*....82
Engineering Research in Chemical Organizations. By *Crosby Field*....84
Recent Chemical and Metallurgical Patents....86
Synopsis of Recent Chemical and Metallurgical Literature....88
Reinforced Waterproof Paper....90
Book Reviews....90
Personal....90
Obituary....91
Current Market Reports—Non-Ferrous Metal Market, the Iron and Steel Market, the Chemical Market and Chemical Price List....91
Industrial News—Plant Construction, Catalogs and New Publications....95

The Outlook of the Optimist

NOW is the time to be optimistic. And we will be if we are thoughtful, for it is mainly the thoughtless and heedless who comprise our minority of alarmists and pessimists. Our country has just completed the most gigantic task ever set for it since the day when it achieved political independence. By the same token it faces, with the other great nations of the world, the most momentous problems in human history. Having been successful in overcoming the military forces of the enemy by performing stupendous tasks of organization and production, are we to face less resolutely and with less hope, confidence and courage the problems of government, of labor, of food, of production and distribution, of demobilization and reconstruction?

Let us think for a moment and try to realize conditions that are average and general instead of those that are isolated and specific. The pessimist says there is a shortage of this or that. The optimist retorts that the shelves of the world are bare—and he is right. The pessimist says that the Governments of the world have destroyed billions of dollars worth of material property and that we face ruin. The optimist replies that the people of the world hold securities for billions of dollars, and are richer thereby, with more floating capital and quick assets as buying power than they ever had before. The pessimist sees parts of the world ragged, shabby, hungry, oppressed and distressed. The optimist knows that they are but waiting to spend their money for clothing, food, the necessities and even the minor luxuries of life and that the ideals of the world's leaders promise better conditions for mankind than we have ever known.

For several years we have had unprecedented prosperity. Those who are far-seeing know that the next few years also will be years of plenty. It is merely the gulch, the chasm that lies between these two heights, that gives pause to the thoughtful and brings visions of panic to the thoughtless. The spanning of that gulch can be accomplished just as surely as we raised an army of several million men, just as surely as we turned our industrial machinery from peace to war, just as surely as we raised billions of dollars to support and supply our armies. And we accomplished those things by creating a spirit of confidence in our ability to do them, by uniting the whole country in the thought that although the task was stupendous it nevertheless was feasible.

This is what we must do now with regard to the future. We know that prosperity is just ahead. We must not delay its coming, or rather break its continuity, by becoming alarmed at high wages or isolated

instances of over-supply. Production must be continued and stimulated because there is going to be the demand. We must be glad to see high wages, but we must get an equally high return for them. All standards are higher than they were four years ago—standards of living, wages, production and morals, and there is every reason why they should be maintained on that high level. The need of the world is a new vision, adjusted to the new order. Reconstruction does not mean a return to the old, but an adaptation to the new and best that has grown out of our troubles. Optimism is the order of the day, and the duty of every thinking man is to see clearly and largely and spread the gospel of confidence and our ability to achieve.

Faith in Our Friends and Allies Across the Atlantic

LET'S begin with a parable. Once there was a man who had a son, and the son was a lively boy. He was full of zip and ginger, and as he grew up he displayed great curiosity to know what was going on in the world. Now the father was a cautious man and, knowing the temptations to which all flesh is heir, he admonished the younger one against the many dangers which beset his path. He said to himself that one cannot be too careful, and he watched in secret and listened diligently to whatever reports were brought to him by others, wherefore he was convinced of his son's waywardness even until his suspicions were greater than their warrant. So disagreements arose between father and son and neither trusted the other. And the son persevered in the pursuit of evil, while the father ended his days in sorrow and bitterness.

There was also another man whose son was like unto the first, but the father had faith in him and trusted him. When he was wayward and became entangled in difficulties, his father helped him and sympathized with him, remembering his own early days. Neither would the elder man listen to any evil word that was spoken of him, for, said he, he is mine own son and I should be false to withdraw my faith from him. In the process of time the young man mended his ways and persevered in the paths of righteousness, so that great honors were bestowed upon him. And the twain spent their days in amity and delight. Selah.

Now we have the beginning of another year with victory in our hands, and we may well ask ourselves what we shall do with it. The problems are so many and so great that we are all as little children before them; while the responsibilities are so ponderous that every one who participates in American citizenship has obligations as great as those of a father. What, then, shall we do with this victory? It is not ours alone. Have we earned more of it than our brothers of England, or France, or Italy, or Belgium? We have more of its fruits, but, much as we have paid, our cost has been less than theirs. We cannot deny and we should not forget that for three years they fought our battles. While they were doing this we sold them munitions and thus became the great creditor. Now a great creditor also has obligations like those of a father. Shall we hold fast to our faith in Englishmen and Frenchmen and Italians and Belgians just as we did when our boys were fighting beside theirs? They have borne much and they are sore wounded. They are very likely to say things and do things and want things that do not seem fair to us. It is excellent to let any one who disagrees talk himself out. Then if we do not respond in anger and thus put him on the defensive, he will not mean everything he has said, after all.

We can carry chips on our shoulders and tell our allies in war that we saved their skins and we can boast and browbeat everybody until we look and sound like so many Germans of the style of 1913. We can incline our ears toward WINSTON CHURCHILL and suspect that Great Britain is resolved to rule the seven seas with a rod of absolute authority and that none but Englishmen may command a ship and none but Scotchmen may operate its engines. There are always enough Fenians and German propagandists running loose to urge us to beware of this hazard that does not exist and never will unless we conjure it up with the help of hate and malice. There are vast possibilities of the development of electrochemistry in France, and because we must hustle to keep our end up in this respect (which is a good thing for us), we can declare that France is more of an enemy than a friend. And then, once our suspicions are well aroused, there's no reason why we should not shiver and fear lest the Belgians be getting ready to eat us up. It would be quite as reasonable. Once we get to thinking along this line it is easy to go on. The Belgians were the ruination of Germany, and Germany was a great nation in her day. Broad is the road and easy the way that leadeth unto trouble.

On the other hand we can keep on believing in our friends across the sea even when things look all wrong and everybody seems disposed to put up tricks against us. Of course we must use our heads and look after our affairs, because things are so ordered in this world. Intelligence is expected. That is the reason guardians are appointed for incompetents. But the main thing is to keep good natured over our job, to make only fair and just proposals and to hold in mind the vast difference between wisdom, which is safe, on the one hand, and shrewdness, which is explosive, and suspicion, which is poisonous, on the other. That second father in the parable knew very well what the boy was up to, but his virtue was that he would not listen to anything that might make him angry. He knew all the time what he was about; but he kept up his faith in spite of everything. That is what we must do.

Scrutable in the Penultimate

THE *Canadian Chemical Journal* takes us severely to task for expressing regret that the president of the Honorary Advisory Research Council of Canada, Dr. A. P. MACALLUM, should hold the opinion that, while it may be inscrutable in the ultimate, there are reasons why international co-operation is inadvisable.

Now the last thing on earth that we want to do is to foment discord, and one of the easiest ways to cause it is to argue that a kindly neighbor who criticises is in error. We do not and did not mean to discourage Canada in research; in our hearts we want to encourage it, but if our Toronto neighbors conclude from our utterances that we indicated a slant toward such discouragement, the best that we can do is to protest our innocence. We want to see Canada among the world's

leaders in science, in the arts, and in the good things of life, with prosperity included.

We have searched our souls in wonder how, if this intimation which we did not mean and cannot see, is present in our comments, it happened to hide itself there. They are keen readers in Canada, and we respect their scholarship, literary as well as scientific. Knowing well how unconscious motives play the very devil with the best of us, we have reached the conclusion that, if the meaning is there, our words may have been tinctured with jealousy. We are rather fond of turning phrases ourselves, and we confess that we never thought of the expression "inscrutable in the ultimate" until Professor MACALLUM invented it.

We try to give our readers as fine a chemical and metallurgical journal as there is in the world, but the barriers of speech do encompass us all. And if Canadian professors bring out novelties like "inscrutable in the ultimate," we cannot resist the temptation to use the expression in comment. Nevertheless we maintain certain reservations of conservatism ourselves, for lately we decided not to print an article involving "foremanizing" and "functionalization." At the ruling prices of metals we do not want to strain our type. Nevertheless we would rather buck the antimony market than leave anything unsaid in support of proper modesty, or that might hinder us from the enjoyment of amity among our colleagues.

Capacities Well Aligned in the Iron Industry

THE obvious fact that the steel industry emerges from the war with a much greater plate rolling capacity than existed before the war might suggest that the war disarranged the alignment of capacity in the iron industry as a whole in a number of respects. A scrutiny of the situation indicates, however, that really the industry emerges from the war, with all its intensive and extensive new construction, in remarkably well balanced shape. Claims to the contrary are made, but they come from the commercial rather than the technical ranks. Some merchant blast-furnace men have undertaken to argue that there are not enough blast furnaces to go around and that if the steel mills are called upon to operate at capacity pig iron will command a higher price in the market, in relation to billets, than has obtained in the past.

Considering commercial capacities, ability to produce material under normal and reasonably favorable conditions, the existing pig iron capacity may be taken at 45,000,000 tons a year and the capacity in steel ingots and castings at about 50,000,000 tons. To the uninitiated, possessed merely of a knowledge that pig iron serves the double purpose of making iron castings and making steel, this might seem quite awkward at the outset, but the fact is that "steel production" as commonly reported in the form of ingots merely represents the record of the ingot scales. The material is subject to scaling and shearing, and while the scale is lost in the balance, when it goes through the blast furnace and appears as pig iron production, the scrap goes through the blast furnace and makes its second trip over the ingot scale.

The year 1916 was quite a normal one in respect to operations in the iron and steel industry. There were 39,434,797 tons of "pig iron" produced, of which 32,522,078 were bessemer, basic, low phosphorus, ferromanganese and spiegeleisen, and 6,912,719 tons were foundry, ferro-silicon, malleable, forge and unclassified. There were produced 41,401,917 tons of steel ingots and 1,371,763 tons of steel castings, making a so-called total "steel production" of 42,773,680 tons. Of finished rolled steel, however, including unfinished steel exported, there were produced only 30,557,818 tons.

The first named, pig iron, 32,522,078 tons, may be considered steel making iron for the purpose of this analysis. It represented 76.0 per cent of the weight of the 42,773,680 tons of steel ingots and castings produced. By the same proportion, 50,000,000 tons of steel ingot and casting capacity at present require 38,000,000 tons of pig iron. With 45,000,000 tons blast furnace capacity there are left 7,000,000 tons of pig iron for gray iron and malleable foundries and puddling furnaces. The amount in 1916 was 6,912,719 tons. That the demand does not grow as does the demand for steel products is indicated by the fact that the corresponding amount in 1910 was 6,748,886 tons.

This makes a clear case that according to precedents there is no shortage of pig iron in prospect, but there are two other facts which indicate that if there is any disturbance in the balance it is in the other direction. In 1916 the United States exported 212,765 tons of scrap and 607,236 tons of pig iron. It can hardly be maintained that, from an economic standpoint, we ought to export those materials. Why not export iron ore, also coke, or, better still, coking coal? The second fact is that the present new construction program involves about 1,000,000 tons of steel ingot capacity and materially more than 1,000,000 tons of pig iron capacity, whereas 760,000 tons of pig iron would take care of 1,000,000 tons of steel ingots.

These computations are not conclusive as to what will occur. What they do show is that there is no basis at present for concluding that pig iron will be scarce relative to steel or that it will be particularly plentiful relative to steel. When it comes to the test, under favorable conditions, blast furnaces, steel making departments and steel rolling departments are all more or less likely to exceed their ratings or break previous records, and no one can tell which department would come out ahead in the race.

As to there being a proper balance at this time between steel making and steel rolling and finishing capacity the case is not so clear. Throughout the war, it is true, rolling capacity was found for all the ingots produced, even the altogether unconventional ingots produced in steel casting plants as a war-time measure, but there was much shell steel produced, with little rolling, much of it passing to the forge shop in large sections. An abnormal tonnage of plates was produced, but such a tonnage will still be required. If, however, any shortage of rolling capacity develops it can be remedied much more readily than a shortage of pig iron or steel making capacity.

Thus the iron and steel industry is well balanced within itself. Whether it is well balanced against commercial demand for the product, when its capacity is 114 per cent greater than the output in 1906, an extremely good year in its time—that is another story, on which the future will throw light in due time.

Readers' Views and Comments

Ferromanganese

To the Editor of Chemical & Metallurgical Engineering

SIR:—I observe in the Dec. 15 number on page 794, under the heading of "Missing Page From the Blue Book Speller," your article on the subject. You certainly could not hit the target and ring the bell better than you did in this article. I will endeavor to answer the question that you mention.

If manganese ferro-alloy is dropped into an empty hot ladle and the ladle then filled from the crucible of steel, the mixture will be perfect, as it requires between ten and forty seconds to completely fuse the manganese ferro-alloy. I find that this method makes a stronger casting and absolutely no segregation takes place.

A. R. BALCOM.

. Toronto, Canada.

Colloids in Flotation

To the Editor of Chemical & Metallurgical Engineering

SIR:—In an article entitled "Colloids in Flotation," *Mining & Scientific Press* of Oct. 12, I endeavored to explain some vagaries of the flotation process. In your issue of Nov. 15, Mr. A. Schwarz has dissected the article and subjected its author and his profession to some abuse for calling a certain substance colloidal matter. I am offering no apologies for having written the article, but would like to clarify certain points that received a broadside of condemnation.

The statement that I had "written with a total ignorance of the actual meaning of colloid chemistry" was clearly ill advised in view of the opening statement of my article in these words "the very fine amorphous material in crushed ore usually spoken of as colloids or colloidal matter." Colloidal matter is a term used in the absence of a better one for this particular substance. It is fine, amorphous, difficult to settle, hard to filter out, sometimes passing through the filter very much as does the water to which it imparts a velvety sheen. That it may contain colloids is recognized by the United States Bureau of Mines[1] which notes the presence of such colloids as kaolin, iron, aluminium hydroxide, tungstic acid, molybdic acid; and more particularly colloid silica as noted by Courtenay De Kalb[2] in this statement, "Common hydrophilic colloids are soaps, gelatin, albumin, casein, and silicic acid. The last is produced in mill pulp as a result of attrition on the ore. The longer and the more finely the ore is ground the larger will be the hydrophilic gel-colloid present in solution." Whether these colloids are flocculated or not the subject under discussion can be referred to, even in the presence of granular material, as colloidal matter without necessarily being ignorant of the meaning of colloid chemistry. It is interesting to note that the conclusions reached in technical paper No. 200 of the United States Bureau of Mines are almost identical with those stated in my article as to the deleterious effects of colloids in flotation. Here are the two conclusions, and it matters but little which you take. "If a considerable amount of colloidal material is present, its elimination, or at least the elimination of its effects, will be necessary," and "the elimination of all, or nearly all colloidal matter very likely would end most of our flotation troubles."

Mr. Schwarz proceeds to tell us that "beyond all question of doubt the flotation process is absolutely fundamentally based upon the colloids from oils, tars, intermediate products, and the like used." That may or may not be so, but we do know that oils, tars, and coal tar intermediates are not necessarily effective agents in selective flotation. They may be effective frothing agents, but the production of froth is not necessarily effective flotation. I have seen froth a foot deep that carried relatively less mineral than the original ore. In my work on feldspathic ores I have reduced the froth from a cross-section area of 300 sq.in. to 2½ sq.in., and thereby increased the recovery 100 per cent. Froth is not sufficient in itself, nor is a colloid. If a colloid were sufficient, it should be feasible to float the minerals with the colloids in the ore. If the presence of colloids in the ore is denied, and a colloid is "absolutely fundamentally" essential, how can we explain the successful flotation of ores by the use of the alkali chlorides?

We are greatly in need of information as to "Why is flotation?" As I mentioned in an article on flotation tribulations[3] one should study his problem in the light of the theory applicable, but that in flotation while everybody has satisfactory results, nobody has a satisfactory theory. Ingenious theories have been advanced and upheld with as much dogmatism as Mr. Schwarz holds the colloid theory, nevertheless they have perished. The colloid theory has much merit, but that it is "absolutely fundamentally" so is open to question at this early date. Theories should be accepted in view of the percentage of the total known facts they comprehend, and never in our time as absolute. Centuries of experience have taught us that any prevailing theory is one that merely comprehends more known facts than any other kindred theory.

The importance of research work in colloidal chemistry or in any other line of study is to be emphasized, and was so stated in my article, but qualified in these words, "by those in position to do it." Which again brings up the question of research work with reference to applied metallurgy. If one canvasses the whole world of concentrating mills and cyanide plants, he will find but few laboratories sufficiently well equipped for carrying on the research work that the subject demands. Also he will find very few men sufficiently well prepared for this work who have the time to devote to it. Usually the man detailed to get results, whether manager, superintendent or foreman, has his hands well filled in keeping the plant in operation, in keeping up supplies and labor, and in performing the simple well known tests incident to his process, and has neither equipment nor time for special research work. He even may be reduced to the expedient of carrying out his cyanide tests with beer bottles tied to classifier gears or thrown upon concentrating tables for the necessary agitation, or of making oil stills from odds and ends of sleeves, plugs and re-

[1]Technical Paper No. 200 U. S. Bureau of Mines.
[2]Control of Emulsions in Flotation. M. S. P. Aug. 18, 1917.
[3]M. S. P. Sept. 16, 1916.

ducers. While excellent results have been obtained in this way, it is inconvenient and a waste of precious time. It is noteworthy, however, that in spite of these limitations nearly all the successful contrivances such as filters, agitators, concentrating tables, furnaces, classifiers, etc., are the result of the patient efforts of those same men characterized by Mr. Schwarz as of "medieval ideas"—the more honor to them! On the other hand, centrally located and privately equipped laboratories or universities with well appointed research laboratories and well stocked reference libraries, and highly trained research men should assume the task of working out the theories and problems necessitating much study and elaborate equipment. That the universities, the United States Bureau of Mines, and the men in the mills cooperating in this work are doing a service of merit is well known, and it is commendable that but very rarely has a member of one branch of the profession had the indiscretion to refer to other members as "ignorant" and "medieval." JACKSON A. PEARCE.

Berkeley, California.

Analysis of Ferromanganese

To the Editor of Chemical & Metallurgical Engineering

SIR:—I am submitting herewith a scheme for the analysis of ferromanganese, which I have used for some time and find entirely satisfactory. When flasks, pipettes and burettes are properly standardized, I consider the Bismuthate method accurate.

A one-gram sample is dissolved in 50 cc. nitric acid, (sp.gr. 1.13) by boiling gently in a covered beaker for about 30 minutes. Transfer to a liter flask and make up to mark. Pipette out 25 cc. into a 250 cc. Erlenmeyer flask and determine manganese by the Bismuthate method. A N/10 solution of potassium permanganate gives a solution of convenient strength, and a ferrous ammonium sulphate solution of almost equal strength is made by using 39.2 grams of the salt and 50 cc. sulphuric acid made up to one liter.

Dissolve a 0.500-gram sample in a casserole with 50 cc. nitric acid (sp.gr. 1.13), and evaporate to dryness. Ignite over a free flame. Cool, take up in hydrochloric acid, evaporate to dryness again and bake for a few minutes at a low temperature. Take up in dilute hydrochloric acid, bring to boil and filter off siliceous matter. Determine iron from filtrate by titrating with N/10 potassium permanganate solution. Ignite residue, weigh as silica and calculate to silicon. This method is accurate enough for metal low in silicon. For metal containing above 1 per cent of silicon it is recommended that the weighed ignited residue from this or a sodium peroxide fusion be evaporated to dryness with a few drops of sulphuric acid and 4 to 5 cc. hydrofluoric acid, ignited slowly and weighed. The difference in weight multiplied by 0.4702 gives the per cent of silicon.

Treat 1.63 grams as for iron and silicon. After evaporating to dryness with hydrochloric acid, add just enough of the acid to dissolve the residue. Warm and convert into nitrates by adding 20 cc. of nitric acid and evaporating twice down to syrupy consistency. Then add 20 cc. of nitric acid, evaporate to about 12 cc., dilute to about 100 cc. with hot water and allow to cool. When solution is between 65 and 75 deg. C., filter into a 250 cc. Erlenmeyer flask, then add, filtering, 60 cc. of molybdic acid solution. Shake for a few minutes, and set aside in a warm place for about one hour. Filter on a weighed Gooch crucible, washing with 3 per cent nitric acid solution, dry and weigh. The residue contains 1.63 per cent phosphorus, therefore each milligram found corresponds to 0.001 per cent phosphorus in the metal.

Bilrowe Alloys Co.
Tacoma, Wash. L. R. TAYLOR.

That Missing Page From the Blue-Back Speller

To the Editor of Chemical & Metallurgical Engineering

SIR:—I have read the article under the above title in CHEMICAL & METALLURGICAL ENGINEERING of Dec. 15 and am surprised to learn that any of the steel plants are still using the archaic method of adding lumps of ferromanganese to the steel in the ladle.

I was with the Robert W. Hunt Co. at the time Capt. Hunt started his then novel inspection of rails from the furnace to the loading dock. During this time I was afforded every opportunity for inspecting the open-hearth end of steel-making. It was a part of my duties to follow each heat all through the mill.

Col. W. P. Barba has good grounds for seriously questioning the additions of lump ferromanganese in the ladle. There is no need to go into the rather difficult investigation of how long it takes a piece of ferromanganese of given size to melt in a bath of steel. This would be a somewhat difficult matter to determine. All that is necessary is to take samples from different parts of the heat to which the lump metal has been added. Samples from the first, middle and last ingots should tell the story. I have found that, given a good tap and the ferromanganese added in small pieces just fast enough and not too fast, you may get the manganese distributed and well mixed through the steel. This combination of circumstances is not, however, often realized.

In most cases the ferromanganese is added too rapidly or in case of exceptionally large charges too slowly. In either case the manganese is not distributed evenly through the metal no matter how much current you may get in your ladle. Manganese once thoroughly mixed with the molten steel will not segregate—it must be thoroughly mixed in the first place.

In one plant it was the practice to add ferromanganese in pieces from $\frac{3}{4}$ to 1 inch in the ladle. In the case of this plant I found very considerable variations in manganese content between the first and last ingots poured. Sometimes the first ingot would carry as low as 0.5 per cent manganese and the last 1.5 per cent. The test from the middle of the heat carried around 1 per cent manganese and was apparently all right. In another plant, one with the best of metallurgical practice with this exception, i.e., that about half of the manganese was added in the ladle, I found considerable variations in the manganese content but not as great as in the case mentioned above. The management of the last mentioned plant made a careful investigation of the question and as a result installed an electric furnace so as to melt the ferromanganese and add it in a liquid state as the furnace is being tapped. This practice gives a thorough distribution of the ferromanganese and saves besides about 20 per cent of the manganese, which under the former method was lost in the slag.

Great Falls, Montana. R. A. DRISCOLL.

Rossiter W. Raymond

DR. ROSSITER WORTHINGTON RAYMOND, mining engineer, editor, author and lawyer, died suddenly of heart failure, on the thirty-first of December at his home in Brooklyn. Dr. Raymond would soon have been an octogenarian, having been born in Cincinnati on April 27, 1840. He spent his childhood at Syracuse, N. Y., and after completing the grammar school grades there, he took a two-year course at the Brooklyn Polytechnic Institute, of which his uncle was president at that time. He was graduated with an excellent record in 1858, and immediately went abroad. While in Europe he attended Heidelberg and Munich Universities and studied mining engineering at the Royal Mining Academy, Freiburg, Saxony.

At the opening of the civil war, he returned immediately to America, enlisted in the Federal Army and served as aide-de-camp, with the rank of captain, on the staff of Maj. Gen. J. C. Fremont, by whom he was officially cited for gallant and meritorious conduct during the strenuous campaign in Virginia which became well known in history, the first time in warfare where underground excavations and mining operations were used in military attacks on fortifications.

ROSSITER W. RAYMOND

Immediately after the close of the war, he returned to New York and engaged in practice as a consulting mining engineer and metallurgist and in 1867 became editor of the *American Journal of Mining*. As his income as editor was not sufficient, Dr. Raymond accepted important additional duties; in 1868 he was appointed United States Commissioner of Mining Statistics, which position he eminently filled, issuing annually for eight years "Reports on the Mineral Resources of the United States West of the Rocky Mountains," and from 1870 to 1882 he taught economic geology at Lafayette College. Dr. Raymond was one of the first to realize the value of professional societies and was not only a charter member of the American Institute of Mining Engineers but devoted the best part of his life to the promotion of its welfare, serving as president in 1872 and 1874; vice-president, 1871, '76, '77 and secretary from 1884 to 1911 and secretary emeritus for the remaining eight years of his life. In 1873, he was appointed United States commissioner to the Vienna International Exposition and during his stay in Europe was invited to address the Iron and Steel Institute at Liege, Belgium.

From 1875 to 1895 Dr. Raymond was consulting engineer with Cooper & Hewitt, proprietors of the New Jersey Steel & Iron Co., the Trenton Iron Co., and numerous iron ore and coal properties. As president of the Alliance Coal Co. and through his association with the coal operators of Pennsylvania, especially with Frank B. Gowan, he became well acquainted with the facts concerning the memorable campaign against the "Molly Maguires." His activities in regard to labor questions made him known as a courageous and fearless opponent of all tyranny practiced in the name of labor and his articles on "Labor and Law," "Labor and Liberty," etc., published in the *Engineering and Mining Journal* at the time of the Homestead riots attracted world-wide attention.

Dr. Raymond was a deep student of legal matters and was admitted to the bar of the Supreme Court of New York State, and of the Federal District and Circuit Courts in 1898 at the age of fifty-eight. He confined his practice to mining and patent law, in the former of which he was a great authority and on which he gave lectures at Columbia.

As editor of the annual volume of *Transactions* of the American Institute of Mining Engineers, Dr. Raymond reached the highest standard of achievement. He was a master of the English language and had the ability of perfecting the scientific contributions of others so that the words ran fluently, clear, fresh and to the point. He was a constant contributor in the *Engineering and Mining Journal*, where will be found numerous articles both signed and anonymous, which shall always be appreciated for all days to come by the many who have a thirst for information to quench.

In 1884, he prepared for the United States Geological Survey a history on mining law, which was subsequently translated into foreign languages. It is rare that so versatile a person reaches a high degree of excellence in all his endeavor, but it can be easily verified by any of his associates that he did the many things thoroughly. His remarkable personality has become a cherished memory of many members of the Institute and his career a monument among the engineering profession.

Dr. Raymond was an honorary member of the American Philosophical Society, Society of Civil Engineers of France, the Iron and Steel Institute and the Institution of Mining and Metallurgy of Great Britain, and many other technical, scientific and social organizations both at home and abroad. In 1869, shortly before his taking the chair of economic geology at Lafayette, that college conferred upon him the degree of Ph.D. The degree of LL.D. was conferred upon him by Lehigh in 1906 and the University of Pittsburgh in 1915.

In 1911 Dr. Raymond received from Japan the decoration of Chevalier of the Order of the Rising Sun, the highest given to foreigners not of royal blood, in recognition of his advice and assistance to Japanese engineering students in this country.

Dr. Raymond married Sarah Mellen Dwight at Brooklyn on March 3, 1863, by whom he is survived. He is also survived by a daughter, Mrs. H. P. Bellinger, who lives at Syracuse, the childhood home of our beloved engineer, author, editor, lawyer and genius.

Western Chemical and Metallurgical Field

Recovery of Potash From Molasses Fermentation Liquors

By E. Humboldt

THE PLANT of the Mason By-Products Co., on the north shore of San Francisco Bay, is one of the recent additions to the rapidly growing list of new industries on the Coast. Started last fall to take care of the waste of the distillery of the Mason Malt & Whiskey Distillery Co., it is turning out a large amount of stock feed and crude potash for fertilizers. Later on it is expected to produce ammonium salts, acetates, ether and other solvents, and generally to utilize as far as possible all the contents of distillery waste. The distillery is operated exclusively with molasses, both cane and beet, coming from California and the Hawaiian Islands.

At the present time, owing to poor transportation, it is absolutely impossible to segregate the raw material properly. As most of it is received badly infected with bacterial growths and contaminated with formaldehyde and sulphites, the fermentation is rather difficult

PLANT OF THE MASON BY-PRODUCTS CO.

to control. Lack of time has so far prevented any sterilization of the molasses, but a large sterilizer is being erected, which will take care of all the material used day by day, and it is expected that much better results will be attained as soon as it is put in operation. On this account, the composition of the mash varies enormously and the specific gravity of the waste oscillates between 1.04 and 1.06. Consequently it is impossible to give an analysis representative of its contents. As a rule, by calcination it will yield from 4 to 6 per cent of ash containing 36 to 38 per cent of potash.

For various reasons it has been found convenient to separate the yeast before recovering the potash from the waste or slop. It is settled out, pressed and dried, and sold for chicken and stock feed. It contains from 30 to 40 per cent proteids, figured on dry basis, about 15 to 20 per cent ash, some phosphoric acid and a little potash. Cattle are very fond of and seem to thrive on it, provided it is properly used as part of a well-balanced ration. Experience shows it is particularly well adapted to the feed of dairy stock, as it increases the milk production. The amount recovered is not large, and the local market will easily handle the whole output. At the present time no effort is being made to recover anything but the potash, and consequently the slop is stored in a battery of six 150,000-gallon tanks (six more are being built), which deliver it as needed to the evaporating furnaces.

The process is very simple, consisting merely of evaporating the liquid as far as possible, generally about 30 deg. B., then burning it in a reverberatory furnace. These furnaces, four in number, are of the Porrion type, but modified to conform to later designs and to obviate many disadvantages of the old type, being easier to clean and of much larger capacity. Each one has three parts, evaporating chamber, calcining pans and a large combustion intermediate chamber. The calcining pans are fitted with oil burners, and the waste heat is used exclusively for the evaporation. The evaporating side is a large shallow pan, made entirely of brick and arched over, in which the slop is fed continuously; a series of revolving paddles keep the liquid in constant motion, producing a heavy spray, which accelerates the evaporation. Owing to the large combustion chamber between the sections of the furnace, the hot gases coming in contact with the evaporating slop are clean and free from soot, and the temperature at the breeching of the stack very seldom rises above 200 deg. C. It is necessary to admit a large excess of air to the burning pans, which must be opened from time to time for stirring and unloading. To secure the proper draft, each furnace is provided with an exhaust pan leading to the stack.

The feed into the evaporating pan is regulated by automatic floats, and but very little attention is required beyond occasional cleaning, charging a liquid of about 7 to 8 deg. B. and delivering it at from 25 to 35 deg. B. The calcining is done by direct flame up to the time when the charge begins to burn, when the fuel is cut down and a large amount of air admitted. With a little stirring to help, the operation is quickly finished, and the black, blazing clinkers are dumped out and wheeled onto a platform, where the combustion completes itself. As soon as the mass is cool enough to handle it is run through a pulverizer and sacked for shipment.

No attempt has been made thus far to leach the clinker to prepare concentrated potassium salts, as the demand for fertilizer material is much larger than the supply and the foreign char and insoluble ash answer filler purposes for this use. The furnaces are provided with fuel meters, recording draft gages and thermometers, and a perfect control and check of their work is at hand at all times. Besides, the whole installation is run by electric power and is very compact and easily handled. Of the four furnaces built, three are in constant use, the fourth being ready for emergency or switched on when one of the others needs cleaning.

The repair work, after four months' operation with unskilled labor, and general upkeep are fairly heavy, as is usual with most new plants. With proper care and supervision, the three running furnaces will take care of about 85,000 to 90,000 gallons of slop daily and can easily handle all the product of the distillery.

Industrial Efforts in France During the War

A View of the Conditions Under Which the Chemical Industry of France Has Developed During the War — Coal Tar Dyestuff, Synthetic Nitrogen, Alsatian Potash, Algerian Phosphate, Soap and Oil Industries Have Great Possibilties

By Georges Maoussa*

WHEN, a few weeks ago, I had the honor of being requested by Dr. Baekeland to discuss a subject in which I am so deeply interested, nobody dared to hope that this war would end so soon, and that the problems brought forth by the late events would call for such immediate and earnest attention.

When in 1914 the Germans started this war, they thought of conquering the whole world. Besides other things, this military conquest was to establish, or rather impose definitely, an economic supremacy.

Constant toil and tenacity—we have to acknowledge these qualities of the Germans—and unscrupulous commercial methods had opened to the Germans the markets of the whole world, where they had created for themselves one of the first places. If I recall the agreement for the sale of aniline and, in another instance, the sale of fast dyestuffs in this country, it is needless for me to dwell any further on the importance of the commerce in the hands of the Germans and the moral value of their proceedings.

More than in any other field, the Germans had surpassed other countries in the manufacture of organic chemical products. Thanks to this industry, the Germans maintained for a long time material superiority in practical warfare. For obvious reasons I shall not be able to describe the wonderful progress of chemistry in the field of war necessities. In other branches of chemistry the improvements were not less marvelous, and if Germany hopes to find again a hegemony in that line, she will be bitterly disappointed. Be it in Italy, Japan, England, the United States or France, hidden and even unsuspected energies were awakened. Plants were built, and in four years we made ourselves independent of Germany.

Chemical Industry to Have Hard Battle

During the past years the Germans themselves have been far from inactive, and our young industry shall have to fight a hard battle. A trust including all the German chemical plants awaits but a signal to overflow the world at the lowest price with great quantities of finished products now stored in neutral countries.

With a violent commercial offensive, such as the military one we saw in 1914, they will attempt the destruction of this new industry. Generous support of the consumers and protection by putting high duties on German products will help us to face the first difficulties, but only by selling better and more economical products shall we maintain our position in the long run.

For this purpose an agreement between the producers is indispensable. We shall have to avoid the scattering of our efforts, the manufacturing of the same products by many people and competition in the world market. First of all, each country should start only the manufacture of products for which its geographical situation, its mining resources and the adaptability of its workmanship make it desirable.

During the war such reasoning could not hold. But now there is going to be a large overproduction of all the war chemicals, the result of which would be, judging from the normal course of events, strong competition and precipitate decline of prices. It is urgent to figure out what we can expect from each country, and what has already been accomplished.

Coal-Tar Industry

At the eve of the war the situation of the coal-tar industry in France was nothing less than cheerful. How wonderful had been France's contribution at the start of the synthetical dyestuffs industry!

After the discovery of the mauveine by Perkin, the Frenchman Verguin produced fuchsine at Lyons in 1859. Three years later St. Denis, a suburb of Paris, saw for the first time the manufacture of aniline on a large scale by the method of Béchamp. In 1873, the Cachou de Laval inaugurated the series of sulphur dyes and Zacharie Roussin in 1875 was one of the first to make diazo sulphonic acids.

What is left of this promising start? A few small factories operate with small sales, some have disappeared, while others, having kept their French names, are only branches of important German firms.

Under these conditions the private industry was not in the least prepared to meet the enormous requirements of modern warfare. But these difficulties did not dishearten us. Under the presidency of the dean of the French chemists, M. Albin Haller, Member of the Institut, competent chemists assembled at Paris, Lyons and Bordeaux. Manufacturers of Lille and Roubaix, who had seen their factories burned or occupied by the Germans, found credits in banks which up to that time had been hostile to all industrial investments. New plants emerged from the ground as if by miracle.

Essential Plants Moved From War Zone

One of the electrolytic chlorine plants worked till practically under German shellfire, until the situation became unbearable. The High Command sent a company of engineers who moved cells, engines and boilers and a few weeks later a fine chlorine plant had arisen way down south on the banks of the Rhone.

An oil of vitriol plant was on the firing line. The first and second line trenches went through the build-

*Lecture delivered at the Société de Chimie Industrielle, New York, Nov. 19, 1918.

ings. If the least bit of smoke had come from the stacks, German shells would soon have destroyed buildings and equipment. We were in great need of sulphuric acid. In the dark of the night pine trees were brought down from the Vosges mountains and put into the building to support the roof. Then the plant was dismantled. On moonless nights long lines of trucks took pipes, furnaces, engines and the whole equipment to the rear and when finally the enemy discovered that something abnormal was going on in the plant, their shells crashing through the roof hit nothing but the few dried out pine trees. Some time later this same plant produced in another part of France 15 tons of acid daily.

Many Plants Converted to Munition Work

In the heart of France a peaceful looking flour mill, situated on the idyllic banks of a rivulet, astonished the villagers one day by the strange sight of columns of red smoke escaping through the roof. A new nitration plant had been started.

Elsewhere a mineral oil distillation plant was transformed into a nitration plant. But the people interested there were not satisfied with following the ordinary methods. In my opinion, they built the finest nitration plant in the world. No fumes, no smells, none of the precious liquid lost through leaking pipes or connections. The whole process is performed automatically. On one side the hydrocarbons and the acids flow in a continuous stream into the apparatus and without any human guidance run out on the other side a finished product, ready for packing. Only one attendant is present, who looks after the oiling of the machinery.

Not only was there a shortage of the chemicals, but also of men, equipment, steel, iron and foundries. Often we had to make use of rudimental reactions on account of the scarcity of apparatus we had at our disposal.

Chlorine, which so quickly became an important factor in warfare, was not available, and the same was true of electrolysis plants and manganese salts to produce it.

Though an early end of the war was predicted about every six months, the execution of a far-reaching program was started. It comprised some factories which are going to continue their production in the future.

Before the war the output of the French coal mines was 40 million tons a year; 20 more millions had to be imported. Of that whole production seven-tenths originated from the mines of northern France—a part of which was at the very beginning of the conflict invaded by the Huns. The same happened to the iron industry, of which 87 out of 117 blast-furnaces fell into the hands of the enemy.

Production of Toluol and Benzol

The most up-to-date coke plants were situated in these same regions—at Lens, Liévin, Douai—and their loss was a heavy blow to France. Before 1914 the importation in France of coke byproducts amounted to 80,000 tons and the French output of benzol was 10,000 tons.

It was impossible to increase the production of benzol to such an extent as to meet fully the requirements of the powder plants. New coke ovens were built in the coal region of the St. Étienne; others, working with imported coal, at St. Nazaire for instance, improved their yields of the by-products. The gas plants at Paris, Lyons, Marseilles, Bordeaux and Nantes undertook the washing of gas to extract toluol and benzol, by means of which about 6000 tons of benzol and 2000 tons of toluol were obtained. But as these quantities did not suffice, importations had to make up the balance.

In the line of inorganic products the situation was different. We held the second place for the production of sulphuric acid and phosphates. For instance France's contribution was of 1,000,000 tons of chamber acid. The manufacture of fertilizers, which absorbed 75 per cent of that acid, was stopped and the acid turned over to the munition plants. But this amount was far from sufficient. The St. Gobain Cie., whose largest plant was in territory occupied by the Germans, doubled the size of all its other plants which are located in other parts of France. The Société Kullman of Lille built at Port de Bouc, near the mouth of the Rhone, an entire town, with docks, piers and railroad connections, and erected a lead chamber acid works. Other plants grew up on the Atlantic coast at La Rochelle, St. Nazaire, some of these having a capacity of 200 tons of 66-deg. Baumé acid a day. Last year the total output reached more than 2,000,000 tons of 50-deg. acid.

On the other hand there were but few oil of vitriol factories, to supply which a large number of contact plants were installed. Correct statements of their production has never been published. Thanks to a tremendous increase, importations of sulphuric acid could in 1916 be limited to 100,000 tons.

Manufacture of Nitric Acid

In 1913 France imported 320,000 tons of sodium nitrate from Chile, 90 per cent of which was used in fertilizer. Nitric acid was produced on a small scale, and to get the required equipment a stoneware industry had to be created. Up to that day the Manufacture Nationale de Sévres had produced only artistic porcelains. In a short time they were able to turn out any type of stoneware used in the Valentiners, or for picric acid. Besides, the town of Grenoble has become a center for the making of acid proof metals. From 15,000 tons in 1913, the manufacture of nitric acid went up to 600,000 tons in 1916, and the importation of nitre reached 540,000 tons.

The question of fixation of nitrogen was not as vital as in Germany, but nevertheless attention was paid to it. The first plant was built at La Roche de Ham, in the Pyrénées Mountains, and worked on the principle used in Norway. At Briançon, 7500 tons of cyanamide were made; there, the water power was increased and now 200,000 hp. is available, which will give 100,000 tons of cyanamide a year. Other research work has been made in this line, but no results have been published.

As was the case with nitric acid, the lack of chlorine was a serious problem at the beginning of the war. Several plants working with manganese salts had to be shut down on account of the impossibility of getting raw materials. Other plants were started using chlorate of sodium as an oxidizer. The output of chlorate of sodium was so large that we were able in 1915 to provide our allies with 10,000 tons of it, a marvelous increase over the 1000 tons of 1913. Before the war France did not produce any liquid chlorine. About 20,000 tons a year

are being made at present. At the same time, the production of bromine had developed in France and 500 tons is the yearly output.

In 1913 France had an excess amount of 15,000 tons of caustic soda, which she exported. Now things had changed, this quite respectable production, increased by the new electrolytic chlorine plants, was not sufficient, and she had to import caustic.

Such a large amount of raw materials being now available, the production of war necessities took enormous proportions, and in the hands of our brave soldiers these powerful weapons brought in 1916 and 1917 German militarism to the verge of disaster.

In the region of the Alps a single plant turns out 160 tons of phenol a day and in France in 1916 the production of explosives, not including smokeless powder, was 600 tons a day and reached soon after 800 tons and even 1000 tons a day.

The Dyestuff Industry

At first the French army wore red trousers. Experiments had been made on cloth of dull shade, but when trials were made to apply them it was impossible to get the dyestuffs. The imported tinctorial extracts determined the horizon blue, the color which was adopted for the continental troops. For the colonial army every shade and kind of khaki had to be used.

At the same time the Government started the making of indigo, and as nowadays a perfect method for the manufacture of monochloracetic acid has been found, nearly all the cloth for the army is dyed with indigo. Besides the Government producing indigo, other plants started the manufacture of dyes. In spite of the scarcity of raw material and coal, and especially of apparatus and machinery, the monthly production amounted in 1917 to approximately 250 tons and is now about 400 tons. Two-fifths of these dyestuffs were black.

Among the fifty-odd different shades manufactured in appreciable quantities, a great part are sulphur dyes, but also diazo, basic and fast dyes are now on hand. For the purpose of amalgamating these different efforts and giving them new strength, the Cie. Nationale des Matières Colorantes, under the protection of the French Government, has been founded. This concern has at the present time an entirely paid up capital of 71 million francs. The present complications and difficulties have not prevented the company from undertaking and starting the manufacture of indigo, alizarine and different other anthracene dyes. In accordance with the French character, which endeavors to obtain first of all products of quality, particular attention is given to the manufacture of fast dyes.

The dyestuff industry, being the cornerstone of every other synthetic organic industry, has been backed up to a certain extent and will have to be maintained for a while after the war. Other factories could only continue the production of munitions. For instance, the wood distillation output was increased. Hexamethylene tetramine, which up to the present time had been exclusively an imported article, was manufactured at a plant near Nevers. On the banks of the Rhone another factory was founded for the production of formic and oxalic acid, and in the same part of France aspirin and saccharine were made, restrictions having been strongly modified on the latter product.

Agricultural Products Industry Suffers Drawback

The industry of products connected with agriculture was very prosperous, but suffered a drawback during the war. Let us hope that its importance will soon be regained. Marseilles has two great advantages—first, it is a gate to Africa and the Orient and, second, it is the terminal point of the Rhone valley, which has become of such inestimable value in the chemical industry. The pre-war total production of oils at Marseilles alone was 1000 tons per day and her exportation in soaps was 45,000 tons a year.

The situation at Bordeaux is favorable for the trade with Africa, especially Morocco. This country being unusually rich in wheat and oils, Bordeaux is preparing facilities for the handling of these products and a 300 tons of flour per day mill is operating there.

The supply of tinctorial and tanning extracts was sufficient to permit exportations on a large scale as shown by the statistics of 1913; which is 15,000 tons quebracho and 120,000 tons of chestnut extract. But the appetite of the great war machine was not yet satisfied, and again we see the tireless hands and brains of research chemists working on a new process for synthetical tanning material and the result of their effort is a new industry at Lyons.

Without going into any details, I would like to call your attention to the distillation of rosins, centered at Bordeaux; 10,000 tons of the best turpentine are worth while mentioning.

Neither must I forget to say a word about the industry of essential oils. The sunny climate of the blue shores of the Mediterranean is ideal for the growth of flowers; 5,000,000 lb. of rose leaves, 3,000,000 lb. of jasmine, 1,000,000 lb. of violets and more than half a million pounds of tuberose—that is what the fragrant crop amounted to. And the fair sex of the whole world adds to its charms by using 30 million francs' worth of the precious essences distilled from these flowers.

The overproduction in inorganics may only be apparent. Are not the needs of the soil now greater than ever? Impoverished by four years of insufficient care, we have to make up for this neglect with great quantities of fertilizers. Ours is the wealth in phosphates of Algeria and Tunisia; so are now the potash mines of rewon Alsace, and with these raw materials we shall eat up the 2,000,000 tons sulphuric acid and supply the exhausted countries with fertilizers.

Up to the present time all our efforts tended to destruction. Now the same means which made our war machine so disastrous to the enemy are going to be sources of blessing and wealth to the country.

Phosphorus in Copper Alloys

One grain of low phosphorus alloy and 0.25 gram of high phosphorus alloy such as phosphor copper is dissolved in a mixture of 75 cc. HNO_3, 1.13 sp.gr., and 3-5 cc. conc. HCl. After solution is complete oxidize both HCl and phosphorus by adding $KMnO_4$, 2 or 3 cc. at a time, until MnO_2 separates out. About 15 cc. will be necessary. Do not allow solution to boil down. Reduce MnO_4 by oxalic acid, leaving clear solution, add 10 cc. NH_4OH and 50 cc. molybdate solution. Filter off yellow precipitate and titrate with NaOh and HNO_3.

Notes on Electrical Precipitators

A Summary of Observations Taken From Several Installations — Scope of Process Expanding — Power Consumption, Voltage, Velocity and Temperature of Gases Must Be Experimentally Determined — Types of Rectifiers, Electrodes and Insulators

By ERNEST EDGAR THUM

COTTRELL'S electrical process for precipitating suspended solid particles, condensed fume or vapor from a gas stream is relatively familiar to most readers. It depends upon the fact that when such a gas is passed slowly through an electrical field set up between oppositely charged electrodes the gaseous molecules become ionized and the solid or liquid molecular aggregates acquire an electric charge and receive a directional impulse depending upon the potential gradient of the surrounding field. Thus a small current of electricity passes from electrode to electrode by conductance of the ionized gas and transport of the charged particles. In practice the field is maintained by high-voltage unidirectional current, the negative electrodes consisting of a series of small wires, chains, rods or pipes placed axially in pipes or between parallel metal plates. These pipes or plates are grounded electrodes to which the charged particles largely migrate, and may therefore be called "collecting electrodes." Flues for handling the dirty and clean gas and hoppers for temporarily storing the accumulating precipitate complete the essentials, except for the special electrical equipment for current production and delivery.

The Cottrell process has been a godsend to more industries than to metallurgical plants alone. Early developed as a method to mitigate nuisances and damaging fumes, it was soon found that the deposits had considerable value as by-products.

Greater Sphere of Usefulness

The latest installations as an integral part of manufacturing processes point the way for an even greater sphere of application and usefulness. It is only natural then that the application of even such a relatively simple physical principle to so widely different problems should lead to numberless differences in detail. Indeed, success depends upon many different conditions, and a large number of installations are preceded by painstaking experiments to determine the best way to clear the gases of their impurities. It is extremely difficult to predict the power consumption, voltage, velocity and temperature for correct operation until actual preliminary experimentation has been completed on the gas. The general success of the process is testimony to the excellence of these investigations, as well as to the bulldog grit and determination of the operator, since the latter often encounters most baffling vexations which he is prone to ascribe to the design of his plant. As in all cases, the builder should give much attention to the needs of the men who must make the machine run, and it is hoped that these notes, which apply mostly to the larger installations occurring at smelting plants, may be useful in fixing attention on some important problems confronting designer and operator.

The power house should preferably be quite close alongside the treater, with switchboard and windows so arranged that the electrician can at all times have a clear view of his assistant who operates the knocking mechanism and watches the clearance being effected. The operating platform should be strongly and thoroughly illuminated so that mutual signals may not be interrupted by darkness or foggy weather. Should such a layout be impossible for valid reasons, intercommunication can satisfactorily be maintained only by telephone—receptacles should be installed at a number of points, readily reached by short lines from operator's head-sets. By means of call bells the two partners may thus get into intimate contact without delay. As a safety-first precaution in any case, interlocked colored lights on the circuit-opening switch at each unit should indicate whether the high tension current on the treater is on or off.

It should be borne in mind that the operation of the treater plant will be largely adjusted by the appearance of the exit gases. Indeed, in many cases an excellent recovery of values is effected although the visual clearance is poor; thus a fair visual clearance indicates a satisfactory recovery. Therefore the method is not only simple but effective. In a large installation, one man will continuously be watching the condition of the gases issuing from the treater tubes. Proper illumination should be provided so as to permit easy observation through openings glazed with acid-resistant panes, the illumination extending to all portions of the treater's interior. Observation of the gas as it issues from the tubes is most essential when the effluent is mixed with other smoke before being discharged from the chimney, or when handling hot humid gases which condense a cloud of water particles immediately upon mixing with the colder outside air. Watching the smoke from such chimneys evidently is of limited value. In all cases a series of properly made filtration tests is the last resort to determine the actual efficiency of the electrical precipitator.

For the protection of both the man and the treater the plant should be adequately roofed—if conditions are such that a certain temperature of gas in the treater must be exceeded, as discussed later, it may even be necessary to house it completely during the winter. Conditions which make for the comfort of the operators will in nearly every case inure to the benefit of the plant operations. Thus, in case the draft conditions are such as to require the use of a fan it should generally be placed beyond the treater so that the latter will operate as a "suction" chamber rather than a "pressure" chamber. Should the pressure inside a treater be greater than atmospheric, fume and smoke may blow out through the seams and openings—an ab-

solutely gas-tight job would then be required. Again, after shutting off the gas previous to repairing a treater section, the atmosphere in a suction chamber may be cleared in a few minutes, much more rapidly than if it were under pressure.

Power Equipment

The advantages of sectionalizing a large treater plant are obvious. The same is true of the power house. If each section of the treater is connected to its individual electrical supply, that is, if there is a complete set of motors, transformers, rectifiers, voltage regulators and miscellaneous switchboard accessories to correspond to each division of the precipitation plant, it will be possible to operate each section independently of its neighbors and the electrical conditions in it can be adjusted to secure the best results.

Without attempting a discussion of the special electrical machinery which has provided rugged transformers, low speed alternators, rectifiers and special

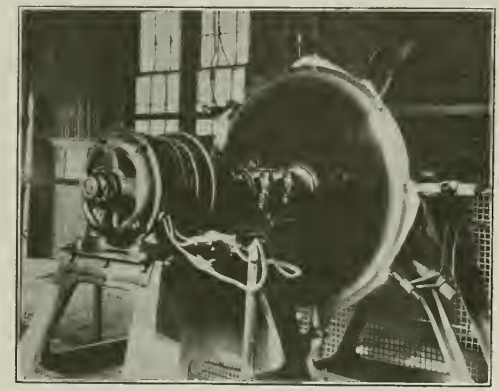


FIG. 1. MECHANICAL RECTIFIER DRIVEN BY SYNCHRONOUS MOTOR

high-tension voltage regulators, it may be said that two methods of current production are in vogue: First, a large alternating current generator of proper rating and design may furnish enough energy for the whole plant, but each treater section will have a separate transformer and its own rectifier driven by a quite small synchronous motor, as shown in Fig. 1. Included in this classification is the case where an industrial circuit of large capacity supplies the transformer-rectifier-treater units. The alternative power house layout shown in Fig. 2 requires a motor, generator and rectifier all on one shaft, the alternating current necessary for the treater unit being generated, transformed and rectified entirely independently of any other unit.

Which of these systems is best is a matter for careful consideration—no dictum should be laid down, since doubtless each has its sphere. Experiments at Anaconda indicate that the wave-form has a determining effect upon the efficiency of the precipitation. Such being the case, commercial current whose characteristics may be suddenly distorted by outside loads should not be rectified. However, this current can be used to drive a single-phase generator especially designed to produce the correct wave-form. Thus it may be that a small motor-generator set working in the second layout may produce a poorer wave-form and more oscillations building up dangerous electromotive forces than a larger machine in the first system, and thus show to poorer advantage. On the other hand in units of large capacity, operating troubles in one section may modify the current delivered to all others from the central generator, so that the latter scheme would then be more satisfactory.

While the first-mentioned power plant is somewhat simpler, it can be installed but little more cheaply than the second when proper induction voltage regulators are included. At most, the electrical equipment costs but 15 per cent of the total, and it is false economy to install unsuitable machinery, since in this case the yearly repairs and renewals may mount to one-quarter the first cost, and unsatisfactory operation cause the whole to be discarded after a short life. Operation demonstrates that precipitating conditions in each treater-unit may vary so much as to require individual electrical control —indeed, ideal conditions are reached when the voltage existing on each discharge electrode can be adjusted.

Spare armatures, of course, will be provided; but a spare transformer is often neglected, although it is nearly as essential. Horn gaps may be used to assist in protecting the transformer insulation, set slightly further apart than the radius of the treater pipes. Ample precautions should be taken to protect all transformers, rectifiers and other equipment. Permanent series resistances in both high and low tension lines are effective in interrupting oscillating discharges and limiting short circuits. Condensers shunted across the generator leads are also useful in absorbing surges reflected from the transformer windings. Adequate lightning and switchboard protection will be suggested by the electrical designer as a matter of course.

It is well to have all the electrical machinery of large capacity. In this relation, the preliminary investigations should determine particularly the electrical characteristics of the precipitated material, since it has been shown that the resistance of the gap between clean

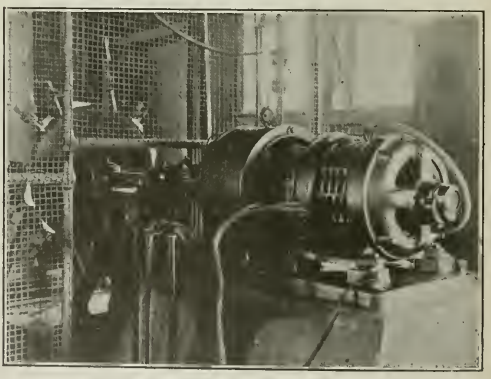


FIG. 2. MOTOR DRIVING A SINGLE-PHASE GENERATOR AND MECHANICAL RECTIFIER

discharging and collecting electrodes may be lowered as much as 50 per cent by a thin non-conducting deposit. The voltage on the system must then be lowered in order that heavy arcs may not trip the circuit breakers. Such discontinuous dielectrics retain their electrical charges

and ionize the surrounding gases if the dielectric constant of the particles be large. The remedy is to make the deposit conductive by humidifying the gas or (in case corrosion is feared) by adding a conducting dust like carbon.

Obviously large voltage regulation may best be had by changing the tap into the low-tension side of the transformer, and close regulation within these steps by adjusting the voltage produced by the alternating current generator. The wave form of the rectified current and to a less extent its voltage is adjusted by rotating the rectifier "brushes" slightly.

Current Characteristics

In order that this may be clear to those who are not well acquainted with such installations, it may be well to diagram an early rectifier quite good for low voltages. This consists of two conducting arms set at 90 deg., insulated from each other and the shaft which drives them. The brushes (which are merely short lengths of trolley wire suitably held in insulated clamps with ends about ¼ inch from the edges of the rotating segments) are also at quadrant points, and are connected as shown in Fig. 3. At the instant sketched the transformer may be assumed to be giving its maximum negative potential to *b* and *c*, while *z* and *w* are correspondingly positively electrified. The positive electricity jumps the short air gap at *w*, travels through arm *v*, across the gap *y* and thence to earth. Similarly a negative current is delivered through brush *b*, arm *a*, brush *d*, and line to the wire electrode. In the treater itself the circuit is completed from charged wire to grounded pipe through the ionized gas.

Fig. 4 is a sketch and Fig. 5 a photograph of the rectifier now commonly used. It consists of a synchronously rotating disk of non-conducting fiber or composition to the edge of which is riveted the metallic

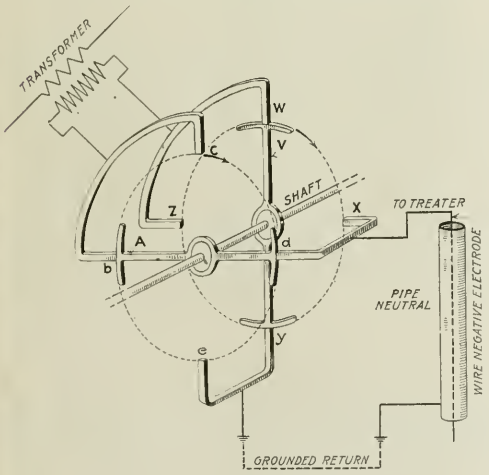


FIG. 3. EARLY RECTIFIER FOR LOW VOLTAGES

quadrants *A* and *V*. Brushes *b*, *d*, *y* and *z* are metallic horns symmetrically fixed in a movable frame. Its operation is quite similar to the older style, and can be easily traced in the light of the following discussion.

Referring again to Fig. 3, the rotation of the arms *A* and *V* interrupts the circuit when the moving end of the segment draws the arc out to a breaking point; meantime the voltage delivered by the transformer is decreasing and by the time the shaft has rotated a quarter-turn the current has reached its opposite maximum. Arm *A* will then be opposite brush *c*, delivering its charge (then positive) to ground through *e*, while arm *V* will deliver another negative impulse from brush *z* to the treater through brush *x*.

In this manner unidirectional, intermittent current is sent to the wire electrodes in the precipitation plant. Reference to Fig. 6 will give the characteristics of the current sent to the treater, where the wave is the

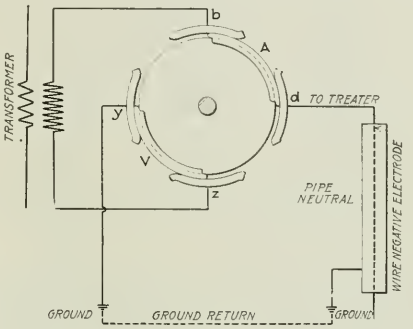


FIG. 4. WIRING DIAGRAM FOR MECHANICAL RECTIFIER FOR HIGH VOLTAGES

ordinary sine curve representing the time-voltage relations of an ideal alternating current. Arm *A* collects the troughs of the waves during a time on each side of the minima shown by dark portions of the curve, while the peaks are collected a half-period later by arm *V*. If all eight brushes are attached to a frame capable of being rotated around the shaft, it is easily seen that turning this frame counter-clockwise will collect the current at an earlier time on the increasing voltage wave. Fig. 7 shows the portion collected in darkened lines as before, and it is plain that each impulse starts at a relatively low voltage, rapidly increasing to the maximum, when it is interrupted. On the other hand, clockwise rotation will first catch the current nearer its crest voltage and deliver an impulse of rapidly decreasing potential (see Fig. 8).

In adjusting the treater clearance it is common for the electrician to throw the brush holder to one limit of its travel, and then move it slowly back and forth until his assistant watching the clearance signals the best location. Then the appearance of the arcing of the rectifier or the reading of a milliammeter on the high tension line is relied upon to exhibit variation in electrical conditions in the treater. Naturally "fine-haired" adjustment of these brushes is not essential, since changing conditions in the treaters demand attention from the operatives at intervals. Synchronism between the alternating current and rectifier is of prime importance, however—this synchronism is evidently absolute when generator and rectifier are keyed to the same shaft.

Since the part of the current wave propelled toward the treater depends upon the potential of the crest, the

width of the air gap and the length of the brushes (as well as the angular setting of the latter), it is evident that the adjustment of the position of brushes such as sketched in Fig. 4 will greatly alter the characteristics of the sparking at the rectifier. The peak only may be collected, resulting in short snappy arcs at the rectifier, or long flaming arcs may almost envelop the circumference of the disk when commutating long portions of

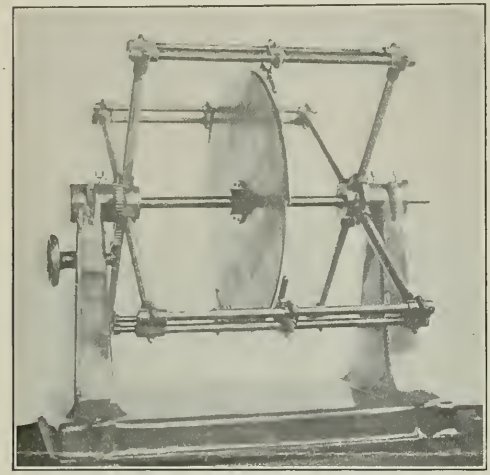


FIG. 5. MODERN RECTIFIER

the wave. The latter obviously transmits a greater amount of energy into the treater.

Constant tampering with the brushes is not conducive to best operation, for if other things are equal the efficiency of precipitation will vary as the impressed voltage. It is therefore essential that the power house deliver uniformly a potential closely approximating that which produces arcing in the treater tubes. The potential wave actually existing across the electrodes is very flat, quite different from that existing at the brushes, since the treater acts like a condenser, and discharges very slowly by transport of charged particles.

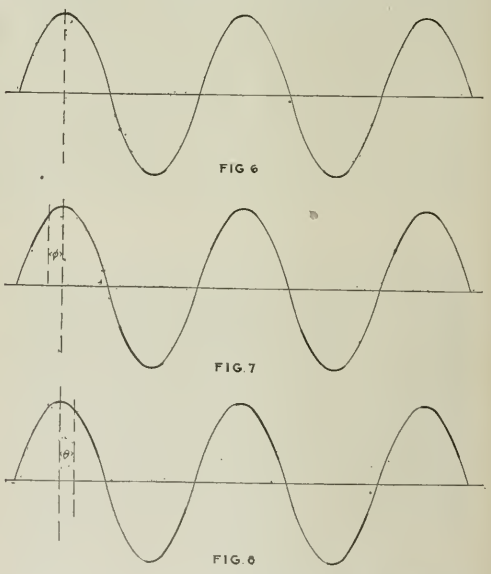
Electrodes and Insulators

Treater construction has been standardized to the extent that the smelter smoke to be cleaned usually flows from a hopper to a collecting flue through upright pipes or between parallel sheets. This whole structure is grounded. The negative current is distributed to wires, chains or thin pipes, stretched by weights or springs through these collectors and accurately centered at both ends by latticed frames. These frames in turn are supported by cross-beams extending through openings in the hopper and flue walls, there resting on proper insulators and protected from accidental contact by a basket or "pent-house." However, it is not desirable to depend upon air seepage to keep the dust from gradually settling on the insulator, especially in case the gas carries free sulphuric acid (as do copper converter and roaster gases).

In the latter case a treater designed to catch dry dust must operate at a temperature above that of any considerable condensation of the free acid, and any infiltering cold air would speedily deposit a tenacious acidic film upon the insulator, causing grounds and punctured insulator petticoats. In such cases it has been found desirable to frame a beam into the ends of those supporting the latticed frames, which beam will extend longitudinally outside the flue walls. This longitudinal beam is then supported by insulators placed centrally some distance from the openings. The whole is enclosed by an iron box, preferably welded air tight at all joints, with weather-stripped doors of glass opposite each insulator, all as shown in sectional plan in Fig. 9. An excellent precaution is to have the levers controlling the high tension tower switch so arranged as to extend in front of these doors when the current is on. In order to get into the insulator box it is then necessary for the attendant to move the switch levers, thus cutting off the current before being able to open the door.

Replacing Punctured Insulators

A large item of upkeep is for replacing punctured insulators, so that careful testing is necessary to get a suitable type. Often it may prove that an inexpensive insulator lasting but a relatively short time will be more economical than a costly one of little longer life. Satisfactory home made insulators are in use on moderate voltages consisting merely of a pile of porcelain slabs, about ¾ inch thick and 6 inches square, alternating with acid-proof tile, of the same thickness and about 3½ inches square. It is hoped that research now under way may develop a new type of insulator which will stand up in warm, dusty and acid-laden atmospheres.



FIGS. 6 TO 8

Fig. 6. When brushes are set at theoretical point of maximum voltage.
Fig. 7. When brushes are rotated counter-clockwise through an angle ϕ
Fig. 8. When brushes are rotated clockwise through an angle θ from theoretical position

The collecting tubes or plates of course should be quite clean and smooth so that no electrical leakage at shortened air gaps may occur. In some installations cor-

rugated iron has been found to be a good material with which to build collecting plates. In tube treaters, it would evidently be good policy to expand the ends of the tube into a pronounced bell before joining into the top and bottom sheets to reduce electrical leakage at the ends.

However, as precipitation proceeds a fume deposit builds up on both pipe and wire, facilitating point-discharges and decreasing the air gap as well. In order to restore the tubes to their normal condition it is necessary to shake this dust free at intervals. Machanical rapping may be done by hammers hung from an oscillating horizontal shaft between alternate rows of pipes striking on welded pads, and a similar hammer striking compression springs fixed on the latticed frames supporting the electrodes. The current of electricity must evidently be interrupted during shaking of the charged electrodes and is usually stopped when

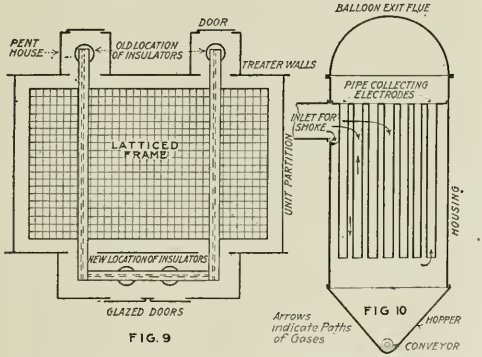


FIG. 9. METHOD OF PLACING INSULATORS DISTANT FROM OPENINGS INTO BODY OF TREATER. FIG. 10. SKETCH OF TOP INLET FOR UNIFORM GAS DISTRIBUTION

rapping the collecting electrodes, but in any case the jarring mechanism should be grounded in two independent ways. In passing, it might be stated that the whole grounded structure should be connected thoroughly and carefully to a return wire. A little trouble and expense here will save foundation piers split by corroding anchor bolts, electrolysis of water mains, and perhaps life itself. All rapping is best done by power, since mechanical operation is independent of human fatigue, and is therefore more efficient and expeditious. The equipment, especially ball cranks and bearings, should be more than amply strong to endure satisfactorily the severe alternating stresses without frequent and vexatious breakages.

Interruption of Gas Current

Whether the gas current should be interrupted during shaking depends largely upon conditions. In large sectionalized installations the provision of one complete unit in precipitator and power plant is desirable. With such a layout one unit may be regarded as a spare and may be continually out of service for cleaning or for repair of any integral part without interfering with the proper operation of the plant. With all units operating, an ample margin for good performance is furnished. If, however, the entire treater plant is working near its capacity, shutting the gas from the unit being shaken will only overload the others, and some loss in clearance and values will ensue. In such cases it would probably be well to rap the plates or tubes at short intervals without interrupting the gas or current, cutting off the electricity only when rapping the charged electrodes at longer intervals. In the case of inflammable or explosive fume it is essential that the treater be large enough that both the gas and electricity may be interrupted during shaking, so sparking may not cause disastrous fires.

The snapping discharge of spark-overs can be heard by the treater tender or located by looking into the upper flue or lower hopper. If a thorough rapping of electrodes will not stop the trouble or if a localized arcing discharge is robbing the bulk of the tubes of their supply of electricity, it may be necessary to shut down the section, and remove the cause. Should this be the presence of dust accumulations, it will be necessary to clean thoroughly each tube by raising and lowering a weighted, special boiler-tube cleaner. Fortunately the dust is strongly adherent only in rare cases—for such it may be necessary to build the balloon flue high enough so that the weighted electrodes may be taken out of the pipes by bodily raising the supporting grid by chain blocks, when a scale-cutter operated by a motor driven flexible shaft can be thrust through each pipe in succession. Such heroic and disagreeable alternatives might be obviated by changing the characteristics of the deposit by proper additions to the entering smoke.

After the electrodes are properly cleaned, centered and weighted, operations should approach normal. Snappy spark-overs do not affect the treater operation seriously, since they consume but little power, and the generating system and transformer are protected from the effect of the momentary short circuit by the rectifier. As is seen from an examination of Figs. 6, 7 and 8, at each half-cycle there is a complete separation between the alternating current supplied to the rectifier and the unidirectional current delivered by it. For 60-cycle current most of these line disturbances are therefore cleared in much less than 1/120 part of a second. Localized arcing is more rare, and is instantly recognized by a jumping ammeter needle and heavy flames at the rectifier. Such arcs should open circuit breakers before damage is done, or can be made to introduce a protective resistance in the low-tension circuit automatically.

Fortunately wire electrodes are seldom burned off or fused, owing to the relatively low amperage of the spark-overs. Considerable difficulty has been experienced, however, in a case where the weighted electrode wires were centered by small holes through the lower grid. Variable resistances at the top caused considerable current to be fed through the bottom spacer—this recurring and localized spark burned off many wires, dropping the weights and shutting down the unit. This trouble has caused the adoption of springs for giving the required tension, but their failure through rapid annealing at elevated temperatures suggests that a more rational solution would have been to have the lower grids carry stirrups which would center a sash-weight of such considerable diameter that its fusion would be impossible.

A thin non-conducting deposit, a thick conducting

deposit or a derangement of electrode spacing may reduce the treater voltage, as already noted. In addition to this, leakage over wet or defective insulators may be very hard to locate and cause serious trouble. Again, at more than 50,000 volts stretched wire electrodes tend to vibrate in elliptical orbits on account of unbalanced attractive forces being suddenly relieved by a local arcing discharge. (Damping rods or the use of chain electrodes cures this tendency—very high voltages may require rigid electrodes.) A further cause of lowered voltage is the screening of the discharge due to a high concentration of dust or fume in the gas. Should the polarity of the charged electrodes become reversed through any cause, a corona discharge will occur at a fraction of the negative potential.

Since the efficiency of the precipitation depends upon the maintenance of the maximum voltage in the treater, constant attention to all such points is required of the careful operator.

Gas Distribution and Temperatures

Properly made experiments preliminary to construction will determine the best conditions of voltage, pipe lengths and diameter for all normal variations in temperature, composition and velocity of the gases. It is not so easy to translate the results attained with one or a few pipes to an installation containing hundreds. Perhaps the most trying thing is the attempt to insure equal gas distribution to all of the dozens of pipes in one section, especially with the low velocities desirable.

If the main intake is merely a pipe opening into the side of the dust collecting hopper, it is evident that there may be large differences in pressure in the collectors with their varying distances from the intake. In some cases the gases are discharged through a ventilator-like hood set in the center of the hopper. Then the corner and middle pipes may suffer. The difficulty of operating a rotating gas distributor in a dust-laden, acid atmosphere can well be imagined. The design should be such as to prevent eddies as far as possible. Evidently nearly ideal gas distribution could be provided in a vertical-pipe treater if set directly above a furnace outlet, connection between the two being made by a straight, uniformly tapering flue. Or, in their passage through a long, straight flue of ordinary construction, if the gases should pass through a section containing vertical sheets and horizontal electrodes placed parallel to the flue walls, they would suffer the minimum derangement in pressure, direction and velocity while going through these narrow passages.

Many peculiar installations may be ascribed to the fact that the precipitator was added to an operating plant where scant opportunity for a correct layout existed. Where head-room is lacking or a tall structure seems undesirable, a distribution as good as any attainable after a sharp turn may be had by introducing the gas near the top of the housing around the collecting electrodes, as sketched in Fig. 10.

Even with the most perfect mechanical design, however, furnace operations vary enough to make large differences in temperature, volume and composition of the gas to be handled. If differential precipitation is to be attempted, close temperature control will be essential so that only the desired volatiles may be condensed. In this case, the treater pipes may be surrounded with adjustable louvers, so that cold air can be excluded or admitted, as the case may be. At the other extreme, it may be necessary to keep up the temperature of the entering gases by previous admixture of hot furnace gases from another source. Fume-laden gases are often cooled, and at the same time their electrical conductivity and efficiency of the precipitation bettered, by water sprays discharging into the flue leading to the precipitating plant. This last method must be used with circumspection, however, if acids are liable to be formed and collected in the precipitator.

Large temperature variations have another profound effect on treater operation besides the fact that a rise in temperature lowers the arcing voltage, which is that it causes large differences in the volume of gas to be treated, and consequently its velocity through the treater. A particle of fume starting up the precipitator wanders about in an indefinite manner until it acquires an electrical charge, when it is impelled to one electrode or the other at a comparatively rapid rate. If the particle is to be caught, the original vertical velocity must not carry it out of the electrical field before it becomes electrified. Recognizing this fact, a careful designer would be justified in adding perhaps 20 per cent to the pipe length which experiments show to be about right, to take care of the unusual velocities which are sure to appear.

Certain operations may produce a fiendish smoke which will not only corrode the metal about the treater but will also precipitate an inflammable (not to say explosive) fume. Fume from Dwight-Lloyd roasters making sinter for lead furnaces, for instance, is highly combustible when the elemental sulphur runs above 25 per cent. (For such plants, adequate fire protection, such as hose, plugs and accessories, should be instantly available.) Walls of acid-proof brick construction would be badly shaken by a flare even after ample explosion doors had blown open. Such conditions have been successfully met by lining a steel skeleton with Johns-Manville "transite board," a type of asbestos lumber which is not only acid proof but is an excellent heat insulator as well.

Combustible dust should evidently be removed from the neighborhood of the electrical discharges as rapidly as collected. Screw or drag conveyors are available for this service, but they should be made several times as strong as the designer ordinarily thinks is necessary so that they may break up and remove the wet, caked dust remaining after a fire has been extinguished without themselves breaking.

Ramsay Memorial Fund in America

It is the desire of the American Committee of the Ramsay Memorial Fund to make the fund an expression of the esteem for Sir William Ramsay in this country. Many have expressed a wish to contribute, but have held back on account of their inability to send in a sum commensurate with their esteem. This has been due to the numerous calls made upon all for the past two years. Small sums, from one to five dollars, will be welcomed by the Committee, which is anxious to make the expression of appreciation as widespread as possible. Contributions may be sent to Prof. Charles Baskerville, Chairman, College of the City of New York, or Mr. W. J. Matheson, Treasurer, 21 Burling Slip, New York City.

Furnace Settings for Caustic Pots

Designs of Radial, Tangential and Reversible Series Dutch Oven Type Furnace Settings for Counter Current Economizer Caustic Soda Pots—The Development of the Most Efficient Modern Types

By FRANK H. NICKLE

In the early furnace settings, adapted for firing caustic pots with coal, the pots were suspended by means of a wide flange at the rim, or a cast iron saddle ring, the weight of the pot in either case being carried by the surrounding brickwork. The grates were placed directly under the pot, thereby subjecting the bottom of the pot to the most intense heat. As larger pots came into use, it became desirable to support the pot on a central pier, thereby relieving the surrounding brickwork of the load and also protecting the lower extremities of the pot from an excess of heat, which had a tendency to interfere with the proper settling of the foreign matter in suspension in the caustic liquor.

An early design of a caustic pot setting is shown in Fig. 1, which is reproduced from the well known works of Lunge. The grates are placed adjacent to the central supporting pier, and within the confines of the brick wall that surrounds the pot. The furnace gases divide on the center line of the combustion chamber and travel 180 degrees in opposite directions around the pot.

The usual practice in this country has been along similar lines, with the addition of a Dutch oven to accommodate longer grates. The Dutch oven is built on the center line of the pot, so as to deliver the products of combustion radially toward the pot, the gases dividing on the center line and traveling in opposite directions around the pot to a common flue connection in the rear. To designate this type of construction, from the writer's improved designs, the same is termed the "radial Dutch oven type."

This radial Dutch oven type, Fig. 2, is illustrated by a battery of two direct-fired pots operating in conjunction with a third or back pot, the back pot serving as an economizer or preheater for the recovery of waste heat from the flue gases. To prevent the direct impingement of the flame upon the pot, a V-shaped vertical fire guard or segmental apron is placed directly in front of the pot. The introduction of this fire guard, although affording a measure of protection to the pot, leads to other difficulties. It restricts the throats at the entrance of the heating passages. In some cases the area of these openings is only fifteen or twenty per cent of the grate surface. If these throats are made amply large, then the support of the rear end of the arch over the combustion chamber becomes a delicate matter, as the diverging walls do not afford suitable skewbacks at the spring line. This makes it necessary to corbel out the rear end of the arch toward the pot in a V-shaped manner, in order to provide a support for the circular brick wall that surrounds the pot directly above the combustion chamber. In this overloaded and weakened condition, the rear end of the arch is called upon to withstand the most intense heat, due to the direct impingement of the high velocity furnace gases and the radiant heat reflected from the fire guard.

The back pot, which serves as an economizer for both primary pots, is usually elevated so that a portion of the liquid contents may flow by gravity to the front pots. As illustrated in the plan view, the flue connection between the front and back pots is sometimes made as short as possible by locating the same on a center line drawn through the front and back pots. This reduces the floor space occupied by the pots; however, the fallacy is obvious. The travel of the heating gases,

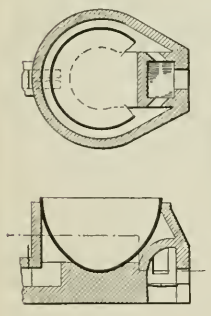


FIG. 1

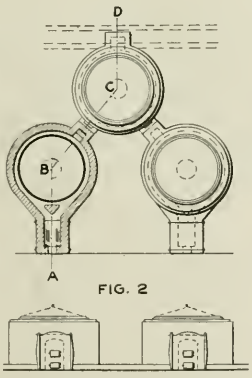


FIG. 2

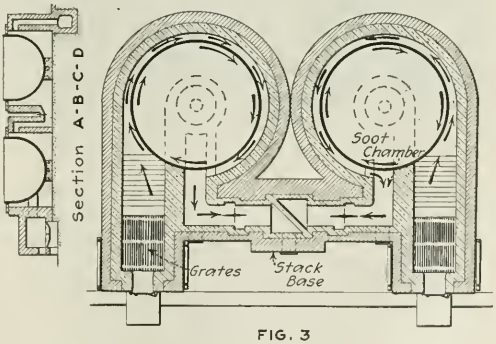


FIG. 3

FIG. 1. EARLY DESIGN OF CAUSTIC POT SETTING. FIG. 2. RADIAL DESIGN OF CAUSTIC POT SETTING. FIG. 3. NICKLE TANGENTIAL DUTCH OVEN TYPE.

in active contact with the front pot, is reduced on one side and increased a like amount on the opposite. This unequal length of travel, about 140 and 220 degrees respectively, naturally causes the heating gases to short circuit and follow the shorter course. Consequently, only one side of the pot, adjacent to the shorter heating passage, is worked to capacity, the volume and velocity of the heating gases being deficient on the opposite side. This unequal distribution of the gases results in a poor natural circulation of the liquor undergoing concentration, also a low rate of heat transmission and

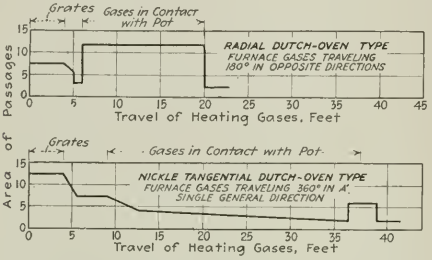
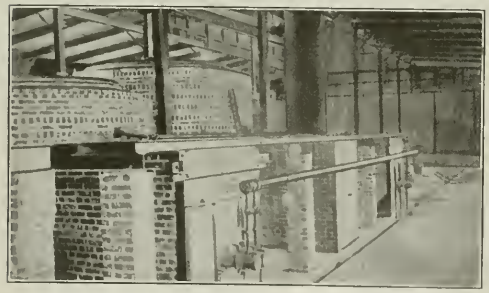


FIG. 4. RELATIVE AREA OF PASSAGES AND TRAVEL OF HEATING GASES.

high temperature flue gases, which makes the use of a back pot more or less imperative. The back pot setting, as illustrated, is subject to the same criticism, with respect to the unequal distribution of the heating gases, especially so when the firing of either of the front pots is curtailed.

Tangential Dutch Oven Type

One of the writer's improved types of furnace settings for caustic pots is shown in sectional plan in Fig. 3. This design, hereinafter termed the "tangential



A GAS FIRED FURNACE SETTING FOR CAUSTIC POTS.

Dutch oven type," consists of a battery of two pots, each being heated by means of a Dutch oven adapted to deliver the products of combustion tangentially to one side of the pot, the heating gases traveling substantially 360 degrees around the pot in a single general direction. At the end of the circumferential travel, adjacent to the combustion chamber, is a soot chamber with a clean-out door. A small sheet iron stack serves each battery, the stack base being located midway between the Dutch ovens.

The usual fire guard construction, to protect the pot from local overheating, is omitted. This leaves the throat back of the bridge wall unrestricted. The area of the passage, where the furnace gases first come in contact with the heating surface, may be conveniently

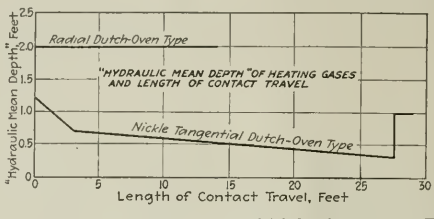


FIG. 5. CHART SHOWING DIFFERENCE BETWEEN THE TWO TYPES.

made equal to 50 per cent of the grate area. This large passage insures a uniform distribution of the gases over a relatively large area of heating surface. It reduces the initial velocity of the highly heated gases and eliminates the blowpipe effect. This desirable feature, together with the tangential application of the gases to the curved surface of the pot, prevents overheating at the initial point of contact.

As the rate of heat transmission is largely dependent upon the velocity of the heating gases, the area of the heating passage is gradually reduced until the end of the circumferential travel is reached. This offsets the

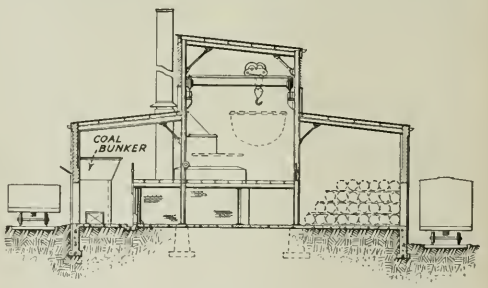


FIG. 6. SHORT SPAN BUILDING FOR CAUSTIC POT FURNACES.

reduction in volume of the gases due to cooling, increases the velocity and favors the effectiveness of the heating surface near the end of the travel. The relatively low velocity of the gases leaving the combustion chamber tends to prevent the entrainment of ashes and cinders from the fuel bed. Accelerating the velocity of the gases lessens the soot deposits in the heating passage and permits the deposition of the soot in the soot chamber, where the velocity is suddenly retarded.

"Hydraulic Mean Depths" Considered

The impartation of heat to a caustic pot is largely by convection, as very little heating effect is derived by radiation from the surrounding brickwork when the brick surface becomes sooted. Consequently, we may say that the rate of heat absorption, by the dry wall of a caustic pot, is largely determined by the length of the gas contact travel and the "hydraulic mean depth" or the average mean distances of the particles of gas from the heating surface.

Comparing the radial and tangential Dutch oven designs, see Fig. 4, the first condition, the length of the gas contact travel, is readily seen to be substantially doubled in the tangential Dutch oven type.

The second condition is not so easily apprehended. The "hydraulic mean depth" is the quotient of the area of the cross section of the gas stream divided by the perimeter formed by the heating surface of the pot touched by the gases. This may be expressed by saying that the closer the gas particles are directed to the pot surface, the more contacts they can make with it in a unit of time. In other words, the "hydraulic mean depth" should be made as small as the draft conditions will permit.

The "hydraulic mean depths" for the two designs under consideration are shown graphically, at any point of travel along the heating passages, in Fig. 5. In each case the gassed perimeter is constant and may be taken as 6.0 feet. The "hydraulic mean depth" for the radial Dutch oven design is 2.00, and may be illustrated by a straight horizontal line, as the flue area is constant. For the tangential Dutch oven design, the "hydraulic mean depth" varies from 1.25 at the initial point of contact to 0.33 at the entrance of the soot chamber, the average being about 0.75.

Advantage of the Tangential Dutch Oven Type

A comparison of the average "hydraulic mean depths" for the two designs clearly illustrates the advantage of the tangential Dutch oven type. It indicates that the gases will make an average of 2.66 times as many contacts with the heating surface in a unit of time. To arrive at this comparison, the volume and temperature of the heating gases leaving the combustion chamber must be the same in each case, allowance being made, in the radial Dutch oven design, for the fact that there are two streams of gases.

Lack of adequate circulation in a caustic pot is also a check to efficient heat transmission. If there is no circulation, the liquor undergoing concentration, or heat treatment, abstracts heat from the pot wall by conduction, which implies no mechanical motion between the contact surfaces of the two bodies. All liquids at rest absorb heat by conduction very slowly. Likewise, a layer of steam bubbles on the heating surface, unless in motion, act the same as a dry gas, the conducting power of which is inappreciable.

The rate of heat transfer, from the pot wall to the liquor, is largely dependent upon the contact velocity of the liquor. There must be an interchange of position between the hotter and the colder particles of liquor in order to permit the heat to flow by convection. The liberation of the steam bubbles is the impelling force that largely effects the desired circulation.

The question now naturally arises—how can the circulation of the liquor in a caustic pot be increased without resorting to mechanical means? The logical answer is, to apply the heating gases to the exterior of the pot in a manner that will promote the rotation of the liquor in a horizontal direction about the axis of the pot. In the tangential Dutch oven type of pot setting, the natural circulation of the liquor is in a horizontal direction concurrent with the circumferential travel of the heating gases, as set forth in the writer's U. S. Patent No. 1,191,338, from which the following typical claim is quoted:

"In a furnace setting for caustic pots, the combination of a furnace, a caustic pot having liquor therein, means to cause the liquor to rotate, said means being the products of combustion applied tangentially to the exterior of the pot and traveling in a direction concurrent with the rotation of the liquor within the pot."

In causing the liquor to rotate in a substantially horizontal direction about the pot axis as a center of rotation, the only resistance encountered is the skin friction between the liquor and the pot wall, the scouring action of which is desirable, as it tends to rub the steam bubbles off the heating surface and promote better contact therewith.

Rotating the liquid contents of a caustic pot not only facilitates the abstraction of heat from the pot wall; it causes the foreign matter in suspension to float toward the center of rotation and settle down out of the zone of active circulation. It thus saves time in settling the highly concentrated or molten caustic soda, improves the appearance of the solid product, and reduces the amount of caustic bottoms to a minimum.

This tangential Dutch oven type of caustic pot setting was first installed, under the direction of the writer, during 1913, by the Dow Chemical Co. at Mid-

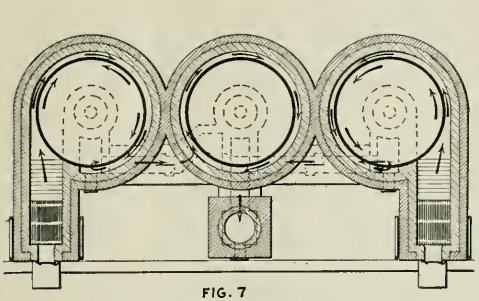


FIG. 7

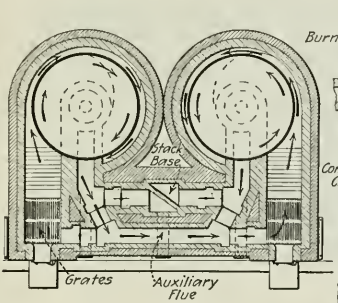


FIG. 8

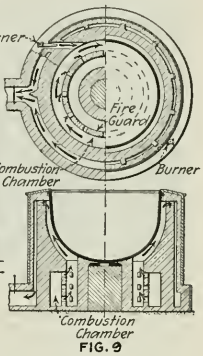


FIG. 9

FIG. 7. NICKLE TANGENTIAL DUTCH OVEN TYPE WITH ECONOMIZER POT. FIG. 8. NICKLE REVERSIBLE SERIES TANGENTIAL DUTCH OVEN TYPE. FIG. 9. NICKLE GAS FIRED TYPE.

land, Mich. The initial installation consisted of four furnaces, which have been subsequently increased to a total of twenty-two. The fire brick arches over the Dutch ovens on the initial furnaces were renewed for the first time during the latter part of 1918, after having been in continuous service for a period of nearly five years. The successful operation of these furnaces has demonstrated the correctness of the principles involved in the tangential application of the heating gases to the pot in a single general direction. Without any economizer or back pot, these furnaces have proved

NICKLE TANGENTIAL DUTCH OVEN IN PROCESS OF CONSTRUCTION.

quite as economical in fuel consumption as the radial Dutch oven type with the usual third or back pot.

Omitting the third or back pot means a saving of about one-third of the investment. Aside from saving the expense of the back pot and the brick setting for the same, it involves a substantial reduction in building costs, as the tangential Dutch oven type is adapted for short span building construction. The general arrangement of a short span caustic shed is shown in cross-sectional elevation in Fig. 6. In this design, the floor space served by the traveling crane is reduced nearly one-half, as compared with the usual layout that accommodates the radial Dutch oven type employing back pots.

As shown in Fig. 7, a battery of two tangentially fired pots may be operated in series with an economizer or third pot. In this arrangement, the flue gases from both of the primary pots travel 360 degrees circumferentially in a single direction around the middle pot. An installation of this type, fired with natural gas, at the plant of the Warner-Klipstein Chemical Co., Charleston, W. Va., leads the writer to believe that the economy that may be effected by the third pot will not justify the extra investment under the average conditions.

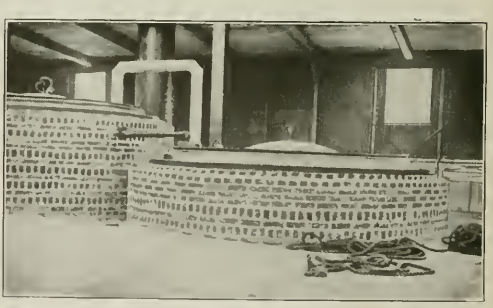
A better way to recover waste heat from the flue gases, without resorting to the use of a third pot, is shown in Fig. 8. This design is the same as the tangentially fired two-pot battery shown in Fig. 3, with the addition of an auxiliary flue and the necessary dampers to enable the operation of the furnaces in reversible series or parallel. When operating in series, either pot may be fired as a primary, while the other serves as a secondary for preheating and effecting the initial concentration of the fresh caustic liquor by means of waste flue gases from the primary pot. A reversal of the dampers converts the secondary pot into a primary and vice versa. The evaporation in the secondary pot may be increased by firing the same lightly to augment the heating effect of the flue gases from the primary setting, otherwise, if desirable, the fire in the secondary Dutch oven may be banked.

Another New Type

Another new type of furnace setting, adapted for caustic pots and various kinds of retorts, is shown in Fig. 9. The following extracts from the writer's pending patent application will suffice for description:

This furnace setting is designed especially for firing caustic pots or other containers with crude oil or gas. An annular combustion chamber, located below the pot and concentric therewith, is made to deliver the products of combustion through a plurality of radial ducts spaced circumferentially in a fire guard that surrounds the circular pier upon which the pot rests. The combustible is supplied by hydro-carbon burners arranged to deliver the blast tangentially to the exterior of the fire guard and in the same general direction of rotation. The radial ducts in the fire guard being at right angles to the direction of the blast, it is evident that the burning gases are caused to travel a considerable distance before gaining entrance to the heating passage at the bottom of the pot.

The endless travel and swirling motion assure a thorough mixing of the burning gases, while the same are being intensely heated by the radiant heat from the wall that surrounds the combustion chamber. This insures good combustion before the gases are subjected to the chilling effect of the comparatively cold heating surface of the pot. The distribution of the gases is uniform around the pot supporting pier, the travel being upward while in contact with the heating surface. This uniform distribution of the gases, without direct impingement of the flame upon the pot, favors the life of the pot. There is no occasion to turn the



COMPLETED INSTALLATION OF NICKLE TANGENTIAL DUTCH OVEN.

pot at intervals to distribute the wear, as is the custom when other types of furnace settings are employed.

Another characteristic peculiar to this type of furnace setting is the use of the waste flue gases for heating the exterior of the fire wall that surrounds the combustion chamber and the pot, the object being to reduce heat losses therefrom by a reduction in the temperature range between the inner and outer faces of the fire wall. An outer wall, concentrically spaced from the fire wall and joined thereto at regular intervals with radial slip-joints, forms a plurality of downtake passages circum-

ferentially arranged and adapted to withdraw the flue gases from the top of the heating passage that surrounds the pot. This construction also provides for a differential rate of expansion and contraction between the inner and outer fire brick walls.

The use of this type of furnace construction is not confined to caustic pots. About thirty furnaces of this type have been installed for the manufacture of carbon bisulphide.

Chemical Engineer,
Saginaw, W. S., Mich.

Platinum Economy in the Industrial Chemical Laboratory

By E. C. Mueser

THE present high price of platinum and recently the real difficulty of obtaining this metal due to Government restrictions in behalf of its conservation for essential war industries, among which were its use in sulphuric acid plants for concentrating pans, its use as contact metal, as catalyzer and other uses, have made it necessary to conserve carefully the analytical laboratory supply of platinum ware. In many laboratories, in order to avoid great expense in replacing this ware and inconvenience due to its shortage caused by difficulty in obtaining new platinum, it was found necessary to make a careful study of the economy of the platinum-ware equipment of the laboratory.

Aside from the importance of conserving platinum ware to avoid analytical inconveniences caused by difficulty in replacing, the platinum of the average laboratory represents a considerable percentage of the total equipment investment, and its rapid deterioration, due to careless or ignorant use, adds very materially to the maintenance and operating costs of the laboratory. In view of these considerations it seems timely to call attention to some basic principles for the proper use of platinum in the chemical laboratory. The first step in conserving platinum ware is, of course, restriction of its use to operations where it is absolutely necessary, that is, where laboratory apparatus, such as crucibles, of iron, nickel, nichrome, alundum or platinum "substitutes" cannot be used because of the nature of the material and the nature of the operation. When platinum ware must be used a careful attention to its proper use will double or triple the life of platinum crucibles and other platinum ware in the laboratory.

The proper care of platinum ware is a matter to which many laboratories have not given the attention demanded by the large investment it represents. In many laboratories platinum ware is frequently ruined through the analyst's carelessness and through ignorance of unskilled routine workers. The proper use of platinum ware should be carefully prescribed in all laboratories and should be restricted to its necessary uses, instead of permitting its use whenever convenient. Some of the platinum substitutes, which, however, are also high priced, may be recommended, and the laboratory chief will find these suited to much of the work which is usually done in platinum. But besides these a large stock of crucibles and ware of silver, nichrome, iron, quartz, alundum, nickel, lead, clay, porcelain and other materials should be on hand, and instructions posted advising for what work crucibles of these various materials are suited. It will be found in many cases that one or another of these materials is very well adapted to the work in which platinum has previously been used.

Many routine analysts work under the impression that platinum is inert to almost any chemical with which he may happen to be working, and some "Dont's" and "Instructions" for its proper use, if posted in the laboratory, would no doubt prevent the ruin of much platinum. In such posters the analyst should be instructed what materials ruin platinum at high temperatures. He should be informed never to place platinum ware in the bare flame or heat it to a temperature approaching a red heat while it contains compounds of lead, antimony, arsenic, silver, tin or bismuth. Also that alkaline earths and caustic alkalies corrode it when heated as well as nitrates and cyanides and sulphur in alkaline mixture. Carbonaceous materials should never be burned in contact with platinum, since small quatities of silica carried by the ash of these materials are reduced by the carbon and combine with platinum, causing it to become brittle.

In heating platinum in the bare bunsen flame it should never be lowered into the reducing cone, but should always be heated in the top invisible parts of the flame. This is also the hottest zone of the flame. The inner cone of a gas flame contains carbon particles and partly burned carbon, which soon crystallizes the platinum and causes it to become brittle due to the formation of a carbide of platinum. If precipitates with their filter paper are ignited in platinum, damage is sometimes caused to the crucible due to the reducing action of the paper. Phosphates and other materials which may injure platinum when reduced in this way should be ignited in porcelain.

Finally, economy and preservation of platinum ware require its proper cleaning. Among the cleaning agents most used are moist sea-sand, with which the platinum is scoured. In some cases fusion with potassium bisulphate may be necessary to clean the metal surface, or sodium amalgam may occasionally be used according to the well known practice.

All the above is of course well known to the average chemist, and the various suggestions made are common practice in all well regulated laboratories. However, in view of the recent difficulty in obtaining new platinum ware and the large investment which the platinum equipment of most laboratories represents, it seemed pertinent again to call attention to some of these rules for the preservation and care of platinum. If calling attention to this matter may help in a little way to extend the life of platinum ware in some laboratories where its conservation and proper use have been neglected, the above will serve its purpose and may assist in conserving the nation's supply of platinum for many essential operations in our industries, in some of which it still finds sole application. Besides this, careful attention to platinum practice may assist in reducing the operating cost in the laboratory where much routine work is handled by analysts with meager technical training.

Badin, N. C.

Dyes and Other Coal-Tar Chemicals

Amendments Recommended to Congress by U. S. Tariff Commission to the Tariff Act of Sept. 8, 1916, Title V on Coal-Tar Crude, Intermediate and Finished Chemicals—New Act to Be Specific—Reasons for Changes

THE United States Tariff Commission has recommended to Congress that the amendments to Title V on Dyestuffs of the act of September 8, 1916, be enacted according to the following edited text, the deleted matter of original act being in brackets and the proposed substitutions or additions in italics. The former act was not sufficiently specific since there were recognized ways of evading duty charges through alternative classifications on such commodities as salol, saccharin, sodium benzoate, phenolphthalein, acetanilid, acetphenetidin, antipyrine, acetylsalicylic acid, aspirin, coumarin, oil of wintergreen, trinitrotoluol, etc. The numbers within the brackets refer to explanatory notes abstracted from the report of Dr. Grinnell Jones on the Reasons for the Proposed Amendments. The full report forms a booklet of 83 pages which is now ready for distribution and to which the reader should refer for further details than given here.

Text Showing Proposed Amendments

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That Title V of an act entitled "An act to increase the revenue, and for other purposes," approved September 8, 1916, be and hereby is amended to read as follows:

Title V.—Dyestuffs

Sec. 500. That on and after the day following the passage of this act, except as otherwise specially provided for in this title, there shall be levied, collected, and paid upon the articles named in this section when imported from any foreign country into the United States or into any of its possessions, except the Philippine Islands and the islands of Guam and Tutuila, the rates of duties which are prescribed in this title, namely:

Free List

Group I. Acenaphthene, anthracene having a purity of less than (3) [twenty-five] *thirty* per centum, benzol, carbazol having a purity of less than (4) [twenty-five] *sixty-five* per centum, (5) [cresol] cumol, (7) *cymene*, fluorene, (6) [metacresol having a purity of less than ninety per centum] methylanthracene, methylnaphthalene, naphthalene having a solidifying point less than seventy-nine degrees centigrade, (6) [orthoscresol having a purity of less than ninety per centum, paracresol having a purity of less than ninety per centum] pyridin, quinolin, toluol, xylol, dead or creosote oil, anthracene oil, pitch of coal tar, (1) *pitch of blast-furnace tar, pitch of oil-gas tar, pitch of water-gas tar*, crude coal tar, (1) *crude blast-furnace tar, crude oil-gas tar, crude water-gas tar*, all other distillates (5) *of any of these tars* which on being subjected to distillation yield in the portion distilling below (5) [two hundred] *one hundred and ninety* degrees centigrade a quantity of tar acids less than five per centum of the original distillate, (2) *all mixtures of any of these distillates and any of the foregoing pitches*, and all other products that are found naturally in coal tar, whether produced or obtained from coal tar or other source, and not otherwise specially provided for in this title, shall be exempt from duty.

Dutiable List

Group II. (10) *Acetanilid not suitable for medicinal use*, (11) *alphanaphthol*, (13) *amidobenzoic acid*, amidonaphthol, (13) *amidophenetol*, amidophenol, amidosalicylic acid, (13) *aminoanthraquinone*, anilin oil, anilin (12) [salts] *salt*, anthraquinone, (13) *arsanilic acid*, benzaldehyde (8) *not suitable for medicinal use*, (13) *benzalchloride, benzanthrone*, benzidin, (13) *benzidin sulphate*, benzoic acid (8) *not suitable for medicinal use* (13) *benzoquinone*, benzoylchloride, benzylchloride, (11) *betanaphthol not suitable for medicinal use*, (13) *brombenzol, chlorbenzol*, chlorophthalic acid, (13) *cinnamic acid*, cumidin, (13) *dehydrothiotoluidin, diaminostilbene*, dianisidin, (13) *dichlorphthalic acid, dimethylanilin*, (13) *dimethylamidophenol, dimethylphenylenediamin*, (12) [binitrobenzol] *dinitrobenzod*, [binitrochlorobenzol] *dinitrochlorbenzol*, binitronaphthalene,, *dinitronaphthalene* (13) *dinitrophenol*, (12) [binitrotoluol] *dinitrotoluol*, dioxynaphthalene, (12) [diphenylaimin] *diphenylamin*, (13) *ethylbenzylanilin, hydroxyphenylarsinic acid*, metanilic acid, methylanthraquinone, (11) [naphthol] naphthylamin, naphthylendiamin, nitranilin, (13) *nitroanthraquinone, nitrobenzaldehyde*, nitrobenzol, nitronaphthalene, (13) *nitrophenol*, nitrophenylenediamin, (13) *nitrosodimethylanilin*, nitrotoluol, nitrotoluylenediamin, phenol, phenylenediamin, (13) *phenylhydrazine*, phenylnaphthylamin, (13) *phenylglycocoll, phenylglycocollorthocarboxylic acid*, phthalic acid, phthalic anhydride, (13) *phthalimid*, resorcin (8) *not suitable for medicinal use*, salicylic acid (9) *and its salts* (8) *not suitable for medicinal use*, sulphanilic acid, (14) *thiocarbanilid*, (13) *thiosalicylic acid, tetrachlorphthalic acid, tetramethyldiaminobenzophenone, tetramethyldiaminodiphenylmethane, toluol sulphochloride, toluol sulphamid, tribromphenol*, toluidin, tolidin, toluylenediamin, xylidin, or any sulphoacid or sulphoacid salt of any of the foregoing, (15) *or of any of the products provided for in Group I;* (16) [all similar products obtained derived, or manufactured in whole or in part from the products provided for in Group I] *all other products by whatever name known which are employed in the manufacture of any of the products provided for in Group II or III and which are obtained, derived, or manufactured in whole or in part from any of the foregoing or from any of the products provided for in Group I;* anthracene having a purity of (3) [twenty-five] *thirty* per centum or more, carbazol having a purity of (4) [twenty-five] *sixty-five* per centum or more, metacresol having a purity of

ninety per centum or more, naphthalene having a solidifying point of seventy-nine degrees centigrade or above, orthocresol having a purity of ninety per centum or more, paracresol having a purity of ninety per centum or more; all distillates (17) *of coal tar, blast-furnace tar, oil-gas tar, and water-gas tar* which on being subjected to distillation yield in the portion distilling below (17) [two hundred] *one hundred and ninety* degrees centigrade a quantity of tar acids equal to or more than five per centum of the original distillate; (18) *all mixtures, including solutions, consisting in whole or in part of any of the foregoing except sheep dip and medicinal soaps, not otherwise specially provided for in this act;* all the foregoing not colors, dyes, or stains, (19) *color acids, color bases, color lakes, leuco-acids, leuco-bases, indoxyl, indoxyl compounds, ink powders,* photographic chemicals, medicinals, flavors, (19) *resinlike products, synthetic tanning materials,* or explosives, and not otherwise specially provided for in this title, (20) [and provided for in the paragraphs of the act of October third, nineteen hundred and thirteen, which are hereinafter specifically repealed by section five hundred and two] fifteen per centum ad valorem.

Group III. All colors, dyes, or stains, whether soluble or not in water, color acids, color bases, color lakes, (21) *leuco-acids and leuco-bases whether colorless or not, indoxyl and indoxyl compounds;* (22) *ink powders;* photographic chemicals; (23) [medicinals] *acetanilid suitable for medicinal use, acetphenetidin, acetylsalicylic acid, antipyrine, benzaldehyde, suitable for medicinal use, benzoic acid suitable for medicinal use, betanaphthol suitable for medicinal use, phenolphtholein, resorcin suitable for medicinal use, salicylic acid and its salts suitable for medicinal use, salol, and other medicinals;* (24) *sodium benzoate;* (25) *saccharin,* (26) *methyl silicylate,* (27) *coumarin, and other* flavors; synthetic phenolic resin (28) *and all resinlike products prepared from phenol, cresol, phihalic anhydride, coumaron, indene or from any other article or material provided for in Group I or II, all of these products, whether in a solid, semisolid, or liquid condition;* (29) *synthetic tanning materials;* (30) [or explosives] (31) [not otherwise specially provided for in this title] (30) *picric acid, trinitrotoluol, and other explosives except smokeless powders;* (32) *all of the foregoing* when obtained, derived, [or] manufactured in whole or in part from any of the products provided for in (33) [Groups] *Group* I (33) [and] *or* II; natural alizarin and (34) *natural* indigo, and colors, dyes (34) *stains, color acids, color bases,* [or] color lakes, (34) *leuco-acids, leuco-bases, indoxyl and indoxyl compounds* obtained, derived, or manufactured (34) [therefrom] *in whole or in part from natural alizarin or natural indigo;* (26) *natural and methyl salicylate or oil of wintergreen or oil of sweet birch;* (27) *natural coumarin,* (35) *and all mixtures, including solutions, consisting in whole or in part of any of the articles or materials provided for in this group,* thirty per centum ad valorem.

Sec. 501. That on and after the day following the passage of this act, in addition to the duties provided in section five hundred, there shall be levied, collected, and paid upon all articles contained in Group II a special duty of 2½ cents per pound, and upon all articles contained in Group III (36) [(except natural and synthetic alizarin and dyes obtained from alizarin, anthracene, and carbazol; natural and synthetic indigo and all indigoids whether or not obtained from indigo; and medicinals and flavors)] a speccial duty of 5 cents per pound: (37) *Provided, That the special duties herein provided for on colors, dyes, or stains, whether soluble or not in water, color acids, color bases, color lakes, leuco-acids, leuco-bases, indoxyl and indoxyl compounds, shall be based on standards of strength which shall be established by the Secretary of the Treasury, and that upon all importations of such articles which exceed such standards of strength the special duty of 5 cents per pound shall be computed on the weight which the article would have if it were diluted to the standard strength, but in no case shall any such articles of whatever strength pay a special duty of less than 5 cents per pound: Provided further, That, beginning six months after the date of passage of this act, no package containing any such color, dye, stain, color acid, color base, color lake, leuco-acid, leuco-base, indoxyl, or indoxyl compound shall be admitted to entry into the United States unless such package and the invoice shall bear a plain, conspicuous, and truly descriptive statement of the identity and percentage exclusive of diluents, of such color, dye, stain, color acid, color base, color lake, leuco-acid leuco-base, indoxyl or indoxyl compound contained therein: And provided further, That, beginning six months after the date of passage of this act, no package containing any such article shall be admited to entry into the United States if it, or the invoice, bears any statement, design, or device regarding such article or the ingredients or substances contained therein which is false, fraudulent, or misleading in any particular. In the enforcement of this section the Sccretary of the Treasury shall adopt standards of strength which shall conform as nearly as practicable to the commercial strengths in use in the United States prior to July first, nineteen hundred and fourteen.*

(38) [During the period of five years beginning five years after the passage of this act] *Beginning September ninth, nineteen hundred and twenty-one,* such special duties shall be annually reduced by twenty per centum of the rate imposed by this section (38) [so that at the end of such period] *until September eighth, nineteen hundred and twenty-five, after which date* such special duties shall no longer be assessed, levied, or collected, (39) [but if, at the expiration of five years from the date of the passage of this act, the President finds that there is not being manufactured or produced within the United States as much as sixty per centum in value of the domestic consumption of the articles mentioned in Groups II and III of section five hundred, he shall by proclamation so declare, whereupon the special duties imposed by this section on such articles shall no longer be assessed, levied, or collected.]

(40) *The Secretary of the Treasury is hereby authorized to make regulations for the enforcement of the provisions of this title.*

Sec. 502. That paragraphs twenty, twenty-one, twenty-two, twenty-three, (41) *one hundred and seventy-nine,* three hundred and ninety-four, four hundred and fifty-two, and five hundred and fourteen, and the (41) [words "salicylic acid" in paragraph one of Schedule A of section one] *provision for salicylic acid in paragraph one; and provisions for salol, phenolphthalein, acetanilid, acetphenetidin, antipyrine, acetylsalicylic acid, and as-*

pirin in paragraph eighteen; and the provision for benzoate of soda in paragraph sixty-seven; and the (41) [words "carbolic" and "phthalic"] *provisions for carbolic and phthalic acids* in paragraph three hundred and eighty-seven (41) [of the "free list" of section one of said act] (43) [and so much of said act or any existing law or parts of law as may be inconsistent with this title are hereby repealed] of an act entitled "An act to reduce tariff duties and to provide revenue for the Government, and for other purposes," approved October third, nineteen hundred and thirteen, are hereby repealed: (42) *Provided, That all articles which may come within the terms of paragraphs one, five, thirty-seven, forty-six, sixty-three, five hundred and one, and five hundred and thirty-eight of said act of October third, nineteen hundred and thirteen, as well as within the terms of Group I, II, or III of section five hundred of this act shall be assessed for duty or exempted from duty, as the case may be, under this act.*

Sec. 503. (44) *That on and after the day when this act shall go into effect all of the foregoing goods, wares, and merchandise previously imported, for which no entry has been made, and all of the foregoing goods, wares, and merchandise previously entered without payment of duty and under bond for warehousing, transportation, or any other purpose, for which no permit of delivery to the importer or his agent has been issued, shall be subject to the duties imposed by this act and to no other duty, upon the entry or the withdrawal thereof: Provided, That when duties are based upon the weight of merchandise deposited in any public or private bonded warehouse, said duties shall be levied and collected upon the weight of such merchandise at the time of its entry.*

Sec. 504. (45) *Except as otherwise herein specially provided, this act shall take effect on the day following its passage.*

Reasons for the Proposed Amendments

1. These tars, although similar to coal tar in chemical nature, and yielding similar products or distillation, are not identical. . . . This close similarity makes it advisable to put all the tars on the same basis.

2. In order to insure tarred oils, etc., being retained on the free list instead of being classified under paragraph 5 of the Act of 1913, the amendment quoted above is proposed.

3. Anthracene is obtained by distilling tar to hard pitch at temperatures around 300 deg. C. When the distillate is cooled, crude anthracene, containing from 25 to 30 per cent anthracene, 15 to 20 per cent carbazol, 20 per cent phenanthrene, crystallizes and can be mechanically separated. The next step is to extract the phenanthrene with an oil solvent, which gives a product containing from 35 to 50 per cent anthracene, which can be further concentrated to 80 per cent anthracene by extracting the carbazol with another solvent. This 80 per cent grade is suitable for the manufacture of intermediates directly.

4. The change was introduced to make only the refined carbazol dutiable.

5. It is evident that considerable orthocresol will distill at a temperature of 200 deg. C. (B. Pt. of phenol 191 deg. C.; orthocresol, 191 deg. C.; metacresol and paracresol, each, 202 deg. C.) The alteration is designed to protect the phenol industry and not put a duty on the primary cresol oils.

10. Acetanilid appears in commerce in two grades—medical and technical (an intermediate).

11. Betanaphthol of a medicinal grade should be dutiable in Group III.

12. The hydrochloride of anilin is usually commercially designated by this term.

14. Thiocarbanilid, made from anilin and carbon bisulphide, promises to be of importance as a rubber vulcanization accelerator and is arbitrarily classed in Group II.

21. The use of the term "leuco" has been broadened to include compounds chemically analogous to the original "leuco compounds" even if not colorless — products converted to dyes by an oxidation agent.

22. A dye which might be classed as an ink powder and be consumed in textile dyeing.

28. The products resemble the resins in some physical properties but are different chemically. The term "phenolic" is unduly restrictive—cresol, phthalis anhydride, coumaron and indene should be included.

36. The only dyes of these classes which were made in the United States during 1917 were indigo, dibromindigo and alizarin. The production of indigo during 1917 was 274,771 lb.—made entirely by one company. At the close of 1918, three companies were manufacturing indigo at a rate equal to normal consumption. It is reported that 1,921,327 lb. of "indigo extract" were made from imported natural indigo. Alizarin was refined on a large experimental scale by one producer. Some so-called "alizarin" or "anthracene" dyes were marketed: "alizarin yellow," an azo dye derived from anilin; "alizarin brown" or "anthracene brown," from phthalic anhydride and gallic acid.

37. It is suggested that a specific duty shall be levied on the basis of the usual commercial strength. It is required that the identity and percentage shall be disclosed to facilitate the assessment of both the ad valorem and specific duties.

An Example of Crystal Crushing

In making physical tests of shell steel, it has come to the writer's attention that certain test bars show a very peculiar structure after fracture. The fractured surface shows a crystalline structure with the exception of a spot in the approximate center of the bar which shows a granular and often a silky appearance. This spot varies from approximately one-quarter to one-half the area of the cross section of the test bar. The writer's first opinion was that during the heat treatment of the bar in question the soaking time before the quench was insufficient. In other words, the time was not sufficient to allow the interior of the test bar to reach the critical temperature.

Subsequent investigations disproved this theory, for upon further examination, by taking another section of the same bar and etching, the grain size showed uniform throughout the entire cross section. By notching and fracturing (by impact), another part of the same test bar showed a uniform crystalline structure throughout. These investigations evidently disprove the theory that the heat treatment was not uniform, but indicate rather strongly that the crystals in the interior of the bar were crushed during the elongating of the bar before rupture.

In the writer's opinion, under certain favorable circumstances, this crushing may extend throughout the entire cross section of the test bar. This may lead to erroneous conclusions as to the condition of the steel. The fracture of a test specimen may be reported as silky or granular when in reality it should have been crystalline.

The metal used in the foregoing investigations was a medium carbon steel. The carbon ranged from 0.45 to 0.55 and the manganese from 0.60 to 0.80. The heat treatment was standard for this class of steel. The test bar was cut from a heat treated 4.7-inch common steel shell, taken from the regular production of the Milton Manufacturing Co.'s plant at Milton, Pa.

Electric Furnaces in the Steel Industry and Their Relation to the Central Station Business

Present Status of Electric Steel Furnace Installations and Their Characteristics in the United States—Electric Power Costs and Rate Schedules—Benefit of Off-Peak Load Hour Operating

GENERAL uses of electricity in the steel industry in the past few years have brought this industry to the attention of electrical engineers as perhaps the largest immediate field for new applications of electricity and large requirements for electric power. Foundries, rolling mills and all forms of steel fabricating plants are so rapidly adopting equipment which requires large amounts of electric power that the question of providing the necessary power is one which demands special attention. These uses of power are varied and some of them are more or less complex, so the services of competent electrical men, either in attendance or available for emergency call, are necessary. These uses comprise general motor drive, rolling mill motor drive requiring special control equipment, welding service for arc, spot and butt welding, oven service for heat treating furnaces, core baking ovens, enameling ovens, etc., lighting service and, lastly, by far the largest of all, service for electric steel furnaces. Electric furnaces require relatively large amounts of power, and their adoption in medium size plants often increases the demands for power as much as 1000 per cent. Since the electric melting furnace is of most vital importance at this time, the following comments will refer particularly to this type of equipment.

Electric Steel Furnaces

There are, according to reports, now in the neighborhood of 300 electric steel furnaces in operation in America. Some of them are located in large steel plants, but the greater number are located in small and medium size steel foundries. Extension in the use of these furnaces is dependent upon an adequate supply of reliable electric power, available at a rate that will enable electric furnace steel to compete with steel produced in other types of furnaces. It is important that the cost of power be as low as the economies of modern large generating and distributing systems will permit, but it is equally important that the supply be adequate and that the service be reliable. Electric furnace installations are invariably followed by complete electrification of the steel plants, and in view of the fact that steel plant operators in general cannot expect to be thoroughly familiar with the various types of electrical equipment involved, it is important that competent electric service men be available for immediate call in case of trouble or in case changes are necessary or additional equipment is required.

Relatively few electric furnaces have been installed in this country excepting where power has been available from the lines of power companies. For this reason furnace manufacturers throughout the early stages of the development have worked hand in hand with power companies, and it should be recognized that the status of the electric furnace to-day is in no small degree due to the careful and persistent efforts of power company industrial and operating engineers.

Furnace Electrical Characteristics

Electric arc steel furnaces have operating characteristics quite different from those of any other electric-power-using equipment. In the early stages of their development chief consideration was given to thermal efficiency, and with this idea in mind a number of furnaces were constructed which proved to have very objectionable electrical characteristics. Among these were induction furnaces with a power factor so low that power could not be supplied to them either satisfactorily or economically. The single phase, long arc furnace followed, which gave not only an intolerably low power factor but required single phase power, placing an unbalance on the generally used three phase power distributing system which introduced difficulties in power distribution that were very objectionable. It was soon found that three phase, short arc furnaces equipped with suitable regulators could be made and would not only accomplish all of the metallurgical requirements but would draw a practically balanced load from a three phase line and produce a minimum of load surging and voltage fluctuation on the line. Furnaces of this type immediately appealed to the electrical men as a step in the desired direction and demonstrated that there is no further necessity to supply power to a low power factor or single phase furnace, unless perhaps to some of very small capacity. We may therefore now consider single phase and low power factor furnaces out of the question and impracticable on account of electrical difficulties.

With even the most improved types of furnaces it is necessary to obtain power from a relatively large generating capacity and to have adequate conductors all of the way from the generators to the furnace. There are wide variations in the power load during a heat, particularly in the melting down stages of a heat of cold scrap. In this period there is a series of instantaneous short circuits causing very heavy loads, interspersed with conditions where the metal changes position and the load is very light. The result is a series of sudden load fluctuations which make it extremely difficult to maintain reasonably constant voltage on the lines and at the generating plant. Unless the power station generating capacity is many times greater than the load drawn by the furnace and unless the lines to the furnace are amply large, the effects of the load fluctuations at the furnace will reverberate through the transmission and generating system to such an extent that the

power plant will be unable to supply other power loads with any degree of satisfaction. For this reason a power company with a small central station should consider the possible effects of a furnace load quite carefully before agreeing to supply it.

Sources of Power

While electric power for a steel furnace may be obtained either from the lines of a power company operating steam or water power plants, or from a special or isolated power plant employing any suitable form of generating equipment, the electrical characteristics of large arc furnaces are such that they can be supplied with power far more satisfactorily and economically from a large generating and distributing system than from a relatively small isolated power plant. Variation in the electric load of a furnace during a heat and sudden heavy loads drawn from the line due to short circuits in the early stages of a heat make it necessary to have generating equipment for an isolated plant at least twice as large as the average load drawn by the furnace. This makes the investment in power plant equipment high, and the low load factor resulting would cause relatively high operating costs. In view of the fact also that furnace installations of from 1½ to 5 tons capacity require a total investment of between $25,000 and $50,000, it would be hardly practicable for the steel company to make an additional investment in power plant equipment in the neighborhood of $100,000.

The usual practice is to obtain power from a central station generating plant and distributing system of as large capacity as is available. It matters not, except in the question of rates in some cases, whether the power is generated by steam or water power. In addition to having large generating capacity and heavy feeders necessary to supply furnace power, central stations usually have an adequate construction and trouble force available for taking care of troubles, repairs and additions in connection with the electric equipment. This, I believe, has been found to be an extremely valuable asset to the steel company in practically every case.

Power Companies Learning by Experience

Power companies have had to learn the characteristics of electric arc furnaces by experience. A number of them have held back on supplying power until they saw the effects of a furnace load and obtained some definite information regarding a rate for furnace power equitable from the power companies' standpoint. Some of them, however, of a more pioneering nature, took chances on some of the early installations and have spent large amounts of time and money in helping to develop furnaces to the point they have reached today. Successful future operation of electric steel furnaces will doubtless depend to a large extent upon close coöperation among furnace builders, steel plant operators and power companies, and it therefore behooves those in these different branches of industry to work together. If the proper types of furnace and accessory equipment are installed so the electric loads will not be too difficult to take care of on a standard power system and if the business will bear a remunerative rate, power companies will be more than glad to supply all of the electric power required and also will contribute quite materially in the line of coöperation in the installation and maintenance of the furnace equipment.

Electric Power Costs

In the operating costs of an electric steel furnace, power is one of the appreciable items. In melting down cold scrap as in foundry work, it often amounts to about 20 per cent of the melting cost. This varies, of course, with the cost of labor and scrap and it also varies with the type of furnace used and the conditions of operation. Under normal nonwar conditions 1c. per kw.-hr. is a very reasonable rate for furnace power, but under present war conditions 1½c. per kw.-hr. is not unreasonable. There is probably little variation in the amount of power used and consequently in the power cost for the different types of the latest improved furnace, the greatest variation being due to the size of furnace used for a given output and the manner in which it is operated. A given capacity of electric power involves a fixed investment and carrying charge, whether it is obtained from an isolated power plant or from a power company, and with the necessary capacity provided and these charges once established they must obviously be distributed over the number of tons of steel melted by the furnace.

Electric Power Rate Schedules

In most cases electric power in the quantities required by steel furnaces is sold under a rate schedule having two factors: (1) a demand charge, or price per kilowatt for the maximum use of power during any given period in a month, such as ten, fifteen or thirty consecutive minutes; and (2) an energy charge, or price per kilowatt-hour for energy used in a month as measured by an integrating wattmeter. The demand charge covers the fixed carrying charges on power station, generating equipment and distribution system investment, and the energy charge covers the variable costs involved in the generation and distribution of electric power, such as fuel, labor, supplies and line losses.

On a two charge rate schedule it is apparent that the resultant rate per kw.-hr. earned is dependent to a large extent upon the number of hours the maximum demand is used in a month, because the demand charge is established by the use of power for a given short period, of say fifteen consecutive minutes, and is the same for the month in question whether power is used for fifteen minutes or 730 hours. The energy charge depends upon the total number of kilowatt-hours used, but there are often decreasing steps in the energy charge schedule so that the greater the quantity of power used the more will be obtained on the lower steps of the rate and accordingly the total net resultant rate will be decreased. This form of rate schedule is perfectly fair to the power user and it is practically the only equitable form of rate schedule under which a power company can furnish power, particularly steam generated power.

Obviously, the advantageous method in operating an electric furnace is to operate it as many hours a day as possible. If a 6-ton furnace operating ten hours a day will take care of a foundry's requirements, they can be taken care of also by a 3-ton furnace operating twenty hours a day. Night forces of men doubtless do not work quite as efficiently as day forces and in a close

labor market they are harder to maintain, but only a few men are required in melting and pouring gangs and in view of the apparently lower power cost that can be achieved there is a decided advantage in operating at night. This may be shown by the following example:

Advantages of Operating at Night

Suppose we have to melt 234 tons of steel per month and consider using either a 3-ton furnace making three heats a day or a 1½-ton furnace making six heats a day; assume that the 3-ton furnace requires a maximum fifteen-minute demand of 900 kw. and the 1½-ton furnace a demand of 450 kw., that 550 kw.-hr. per ton melted are required in either case and that electric power is purchased under the following rate schedule:

Demand Charge—200 kw. at $1.67 per kw. per month; all over 200 kw. at $1.25 per kw. per month.

Energy Charge—50,000 kw.-hr. at 0.7c. per kw.-hr.; all over 50,000 kw.-hr. at 0.5c. per kw.-hr.

In both cases 234 tons of steel are melted, and at 550 kw.-hr. per ton, 128,700 kw.-hr. of electric power are used. In the first case the maximum demand is 900 kw., the demand charge $1208.33, the energy charge $743.50 and the total cost $1951.83, which amounts to 1.52c. per kw.-hr. and $8.35 per ton of steel melted. In the second case the maximum demand is 450 kw.-hr., the demand charge $645.83, the energy charge $743.50 and the total cost $1388.83, which amounts to 1.08c. per kw.-hr. and $5.93 per ton of steel melted. From this we see that by using the small furnace we save $2.42 per ton of steel melted.

Power Factor Is Important

Electric power generating equipment and distributing lines are affected quite materially by the power factor of the power using equipment. Power factor is the ratio of the real power to the volt-amperes in an alternating current circuit. It is expressed in a per cent and is the number by which the volt-amperes must be multiplied to obtain the real power. Real power (P) in a three phase, alternating current circuit is expressed by the product of volts (E) $\times$ amperes (I) $\times$ the constant 1.73 $\times$ power factor (PF), while volt-amperes are expressed simply by volts $\times$ amperes $\times$ 1.73, or P equals 1.73EI and PF equals 1.73PEI. It is apparent, therefore, that for a given amount of real power supplied the current in the generating equipment and distributing lines varies inversely as the power factor. Real power is what is sold, but current is what determines the size of the generating and distributing equipment. If a given power load with unity, or 100 per cent, power factor requires generating and distributing equipment of a certain capacity, the same power load with 50 per cent power factor will require generating and distributing equipment of twice the capacity. The investment will increase accordingly, and naturally the fixed carrying charges will increase directly with the investment. In addition to the increased investment there are a number of operating and metering difficulties due to low power factor.

For these reasons power companies find it necessary to require the highest practicable power factor, and power contracts should therefore contain power factor clauses covering the manner in which power factor will be treated in computing the cost of power under the stipulated rate. The latest types of electric steel furnaces can easily be operated at a power factor between 80 and 95 per cent, and it is very objectionable if a power factor of 75 per cent or lower is obtained.

In the generation of electric power in a steam plant, fuel constitutes one of the chief items of cost, amounting to something over 50 per cent. For a number of years the cost of fuel, particularly coal, has been fairly stationary and power rates have been based on the average cost from year to year, no special provision being made for appreciable increases or decreases. The marked increase in the past two years, however, of something over 100 per cent, brought about by war conditions, has shown the necessity of having a provision in power contracts that will vary the energy charge according to the cost and quality of coal used. Some power companies base their schedule rate on a given cost of 1,000,000 B.t.u. in coal delivered in the company's coal bunkers, and then add to or subtract from the energy charge a stipulated amount for each increase or decrease of 1c. in the cost of 1,000,000 B.t.u. This factor, sometimes called the "coal cost factor," takes care only of variations in coal cost; labor, the other principal item of cost involved, can be treated in a similar manner by using a stipulated base price per "man hour" for labor and varying the energy charge according to increases or decreases above or below that base price.

Long-Term Power Contracts Impracticable

One thing is apparent, and that is that power companies cannot afford to make long-term power contracts at a fixed rate. Rate regulating bodies in the different states, of course, have authority to revise rates at any time and even though they are stated specifically in contracts, they may be changed. Revisions by these bodies, however, require appreciable expenditures of time and money in assembling data and preparing cases and often decisions are reached only after a prolonged delay. It is far better, therefore, that contracts cover probable necessary rate variations as fully as possible.

Load factor is a term referred to by power generating and distributing companies perhaps as often as any other term. It has a direct bearing on the cost of purchased electric power under a rate having a demand and an energy charge as discussed in a foregoing paragraph. It is the ratio of the average power load of a plant to the maximum load for a certain period of time. It is more specifically thought of as the ratio of the number of kilowatt-hours used by a plant in a month to the product of the maximum demand of the plant and the total number of hours in the month, which averages 730. Thus a plant having a maximum demand of 1000 kw. and using 365,000 kw.hr. in a month has a "load factor" of 365,000 $\div$ 1000 $\times$ 730, which equals .50, or 50 per cent.

The reason this term is so important to power companies is that the load factor of the generating plant has a very decided effect on the cost of generating and distributing electric power. Power generating and distributing equipment has to be of ample capacity to take care of the maximum load it is called upon to carry, so the investment is fixed by the maximum load, and consequently the annual fixed carrying charges covering interest, depreciation. taxes and insurance

are fixed. Further than this, power plants must be operated twenty-four hours every day and practical normal operating forces must be maintained regardless of the magnitude of the loads on plants and distributing systems. Labor costs, therefore, change but little whether loads exist for twenty-four hours or for but a few hours a day.

Benefit of Operating During "Off-Peak" Hours

Factories, office buildings and commercial and industrial establishments in general are normally in operation from eight to ten hours a day, starting from 7 to 8:30 o'clock in the morning and closing between 4:30 and 6 in the afternoon with from one-half to one hour shut-down at noon. In winter months the lighting load in offices and factories particularly is heaviest between 4:30 and 7 o'clock in the evening. If the generating plant also supplied power for operating street cars, which is usually the case in larger towns and cities, this load will be found heaviest at the time of the afternoon and evening lighting peak. It is a general condition, therefore, that the central station generating plants and distributing systems have to be equipped to take care of a relatively heavy peak load in the late afternoon, particularly of the winter months, and that for these peaks they have to maintain equipment which is idle at other times. It is at once apparent that a power load which is not used during the peak hours will not require additional generating capacity and corresponding investment and will not increase operating labor costs and consequently can be supplied at a lower rate than "on-peak" power. This kind of a load has attracted the attention of central station companies and most of them are glad to furnish off-peak power at a properly reduced demand charge and correspondingly reduced overall rate. Since electric steel furnaces can very easily be shut down during these peak load hours, furnace operating companies may benefit materially by considering this point when negotiating power contracts.

Similar consideration should also be given to night loads. In some cases furnaces may take care of the desired output by operating only at night, say between 7 p.m. and 7 a.m., and where this can be done a substantially low power rate may be obtained.

Disposition of Munitions

Mr. Benedict Crowell, Assistant Secretary of War and Director of Munitions, has been requested by the President to assume responsibility for the proper disposition of all property acquired by the War Department since April 6, 1917. Mr. Crowell has appointed Mr. C. W. Hare, Assistant Director of Munitions, to have general supervision of this work, and Brig. Gen. C. C. Jamieson has been appointed Director of Sales in direct charge of an organization to be perfected for the disposal of surplus property. It is the intention of the Director of Munitions so to market Government property as to interfere as little as possible with business conditions, and to this end the Assistant Director of Munitions and the Director of Sales will, as occasion may require, confer with committees representing the industries affected.

Information will be furnished by either the Assistant Director of Munitions or the Director of Sales at their offices in the Munitions Building, Nineteenth and B Streets, Washington, D. C.

Separation of Potash Salts

By H. P. Bassett, Ph. D.

In Chemical & Metallurgical Engineering for the past few months much has been written on the potash outlook for this country. Many sources have been discussed, but the potash industry of this country, like the explosive and the allied chemical industries, will be compelled to undergo a decided change.

Potash derived from many of our present sources, such as wood ashes, Western lake brines, etc., will not be suitable for the market under the present system of production. Potash from such sources carries large amounts of other alkali salts, such as sodium carbonate, chloride, sulphate, borax and small amounts of the alkaline earth salts.

These crude salts are used today in our great emergency, but they are not suitable for many trades, especially the fertilizer trade, on account of their high content of other salts, particularly sodium carbonate, which, as is well known, reverts the phosphoric acid when added to acid phosphate fertilizer.

It is also claimed that borax in too large quantities has an over-stimulating effect on plant life. Some authorities, however, state small amounts are beneficial. These points, however, need much further investigation and during the meantime the trade will adhere to the old standards as closely as possible.

National Duty for Chemists

It appears to the writer it is a national duty for the chemical profession to put our present sources in shape to meet the demand they will eventually meet in a peace-time basis. It would certainly be a calamity to let the present sources, such as the Western brines, go out of business on account of the necessary data on which to put them in a healthy condition.

The writer is speaking in general terms, but to illustrate the point more clearly a definite case will be pointed out. For instance, the Nebraska brines usually run about one-third potassium sulphate, one-third sodium sulphate and one-third sodium carbonate. This, however, is sometimes varied by a substantial percentage of sodium chloride. With this illustration before us, it is easily seen with the Nebraska location and the composition of these salts, if those constituents were separated each would have a market value and this field is within the freight radius of some of our best markets for salt cake and sodium carbonate. Of course, the potash would stand shipment even to the last want.

It is, however, different with the case of the brines further West, as these by-products have a very limited market on the West coast. But even in this case shipping high-grade potash salts they could demand the highest price and also save the probable cost of separation in the difference in freight rates.

The writer for several years was interested in the production of potash salts, especially from the silicate, such as feldspar, glauconite, etc., and during the investigation of this work was placed in a similar position as outlined above. That is, in order to make both ends meet, the products produced had necessarily to be separated economically.

With this in view the problem of separation was studied extensively and a number of important points were brought out which may be stated as follows:

1. It is almost impossible to separate a three ion system, for example potassium sulphate and sodium sulphate. This is either due to the formation of double salts or the salting out of one salt by the other on account of common ion. This may be overcome in this instance by the addition of common salt, which has two effects—it produces a four ion system and also tends to salt out the salt with a common ion, namely, sodium sulphate.

2. There is that tendency in any four ion system to form the greatest opposites possible. To illustrate this point, in the above system after the addition of the salt, the greatest opposite that could be formed is potassium chloride and sodium sulphate, consequently the potassium chloride remains in solution while the soium sulphate is precipitated on evaporating the solution.

3. The presence of an alkali or a salt acting as an alkali tends to throw down the heavy acid salts as they exist in solution. To illustrate this point, if we have sodium carbonate or sodium acetate (a weak acid salt which acts as an alkali) the salts, potassium sulphate and sodium sulphate, will tend to be thrown down in the proportion they exist in solution, and this condition will be nearer and nearer approached on evaporating the solution on account of the increase in concentration of the alkali salt. Consequently in the case where we have an alkali present the heavy acid salts like potassium sulphate and sodium sulphate, potassium chloride and sodium chlorite, will have to be thrown out of solution to free them from carbonate and then separated, adhering to the four ion system.

As to how these three so-called laws shall be operated depends on local conditions and original composition of the brines to be dealt with.

Some Laboratory Results

It might not be out of place here to give some of my own laboratory results in a particular case I was dealing with at the time. In the case I had to deal with, the salts in solution were sodium sulphate, potassium sulphate and a small amount of sodium chloride, but, as you will see later, not enough to take care of all the potash.

The analysis of the solution was as follows:

Sp. Gr.	1.100
Total solids in 100 cc., grams	11.340
Total solids by weight, per cent	10.490

Analysis of total solids:

Potassium sulphate, per cent	9.19
Sodium sulphate, per cent	78.35
Calcium sulphate, per cent	0.56
Sodium chloride, per cent	11.90

Of this stock solution 2000 cc., to which was added 20 gr. of salt, was evaporated until a quantity of salts was precipitated. These salts were washed three times on a funnel with hot water, weighed and analyzed with the following results:

FIRST SALT CROP

Weight, grams	54
Sodium chloride, per cent	0.57
Sodium sulphate, per cent	99.29
Potassium sulphate, per cent	0.14

The mother liquor which was wash waters and 1320 cc. more of stock solution to which was added 14 gr. of salt was returned for further evaporation. Four salt crops were then taken out in succession, the weight and analysis as follows:

SECOND SALT CROP

Weight, grams	98.50
Sodium chloride, per cent	0.20
Sodium sulphate, per cent	99.34
Potassium sulphate, per cent	0.46

THIRD SALT CROP

Weight, grams	73.40
Sodium chloride, per cent	0.13
Sodium sulphate, per cent	99.40
Potassium sulphate, per cent	0.47

FOURTH SALT CROP

Weight, grams	35.95
Sodium chloride, per cent	2.08
Sodium sulphate, per cent	89.60
Potassium sulphate, per cent	8.32

After removing the fourth salt crop, 65 gr. of sodium nitrate were added, dissolved in as small a quantity of water as possible, the object being to convert the potash salts into potassium nitrate. This solution was now evaporated and a fifth salt crop taken, which was washed three times with hot water and which gave the following analysis:

FIFTH SALT CROP

Weight, grams	39.20
Potassium sulphate, per cent	0.43
Sodium chloride, per cent	50.06
Sodium sulphate, per cent	48.28
Sodium nitrate, per cent	1.23

The mother liquor was then cooled to room temperature, when potassium nitrate separated out. This was washed three times with cold water and in analysis gave the following results:

Potassium nitrate, per cent	92.96
Sodium chloride, per cent	0.50
Sodium sulphate, per cent	0.39
Sodium nitrate, per cent	6.15

It will be seen that the first three salt crops are good marketable sodium sulphate. The other salt crop and also the mother liquor would be returned to the evaporator and recovered with a new lot of solution to be evaporated, the fifth salt crop furnishing the sodium chloride needed.

The above potassium nitrate can now be recrystallized to produce a pure product or converted into potassium sulphate, as outlined below. The potassium nitrate was converted to potassium sulphate by adding 12 gr. of sodium sulphate from first salt crop to 18 gr. of potassium nitrate. The solution was now evaporated and the potassium sulphate came down from hot solution above grade, analyzing 49.18 per cent K_2O. equivalent to 88.53 per cent K_2SO_4.

The manufacture of sulphate by this process necessitates an extra step, but as none of the nitrate is lost in the operation, the cost will be in the operation.

The sodium nitrate solution can be returned to the point where the nitrate was added; thus the only additional evaporating cost will be in the evaporation of the water added in the dissolving of potassium nitrate and sodium sulphate.

It can be readily seen from the discussion set forth above that by this or some other method it is entirely feasible to produce our potash salts in a high grade form and also recover the other products in marketable form. It might be not out of place and also of interest to note in this connection that by the above procedure the writer has been able to produce ammonia nitrate from ammonia sulphate. In fact the three statements seem to hold for all alkali salts or sodium salts and if followed will, no doubt, form a basis for work much needed at present.

Distillation of Coal at Low Temperature*

THE distillation of coal at a high temperature, such as is actually practiced in gas retorts to extract illuminating gas, takes place under unfavorable conditions from a thermal point of view. According to results obtained by M. Euchène, only 12 per cent of the heat produced by combustion is available for distillation. M. Guénguen, relying on the fact that transmission of heat through the retorts is slight and that this transmission decreases in proportion to the distillation, set about to determine whether it would not be profitable to induce distillation by the introduction of a current of steam superheated to from 500 to 700 deg. His investigations showed several advantages: Shorter distillation periods, distillation accomplished more quickly and more directly, easier liberation of the gas by entrainment and operation at lower temperatures.

In addition, it was of great interest to know whether the coal itself could serve as a raw material for the manufacture of the aromatic compounds as well as for that of the hydro-aromatic and aliphatic compounds, obtained up to the present time from coal tar.

Distillation in a Vacuum

Moreover, attempts have long been made to obtain a better utilization of the coal either by distillation in a vacuum or by distillation at low temperature. Up to now, distillation in a vacuum, studied especially by Berthelot and Pictet, has had no practical application.

In distilling coal under a pressure of 20 mm. of mercury at a maximum temperature of 450 deg., Pictet has obtained 4 per cent of liquid coal tar, containing neither naphthalene nor anthracene, both of which are characteristic of coke-oven tar; however, in heating this tar red hot in incandescent tubes, it is transformed into ordinary tar. Pictet states that the tar obtained in a vacuum contains a greater quantity of phenol than crude petroleum and does not polarize light.

The distillation of coal at low temperature, on the contrary, will perhaps find an immediate and practical realization, thanks to the investigations instituted for this purpose at the special institute for the study of coal created at Mulheim on the Ruhr. (See Génie Civil, March 10, 1917, p. 165.)

Investigating Mineral Oils

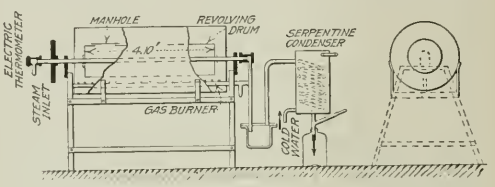
This Research Institute, created by the Kaiser Wilhelm Society to contribute to the development of theoretical and applied sciences, has concerned itself particularly up to the present time with practical questions of immediate interest, notably, the investigation of mineral oils. We know that since the war Germany has lacked oils of all kinds. Lubricating oils which are now used are for the most part mineral oils extracted from petroleum and imported largely from America. It would be very advantageous then for Germany to be able to extract the lubricants which she needs from the coal by distillation.

The investigation of new sources of volatile products, of lubricants or of motor oils has led this institute to undertake a minute study of the chemical nature of coal and also of coal distillation at low temperatures.

*Translated from *Le Génie Civil*, July 7, 1917.

This question is not new; already in 1906 Börnstein, of Berlin, published (Journal für Gasbeleuchtung, Aug. 4, 1906) results of a systematic investigation made by him on the distillation of coal at atmospheric pressure and at a temperature no higher than 450 deg. The coke used was friable and porous, and useless in metallurgy. It yielded a brown tar in a proportion of 3 per cent for the rich coals and 10 per cent for the flaming coals and those not containing free carbon. These tars, studied by Börnstein, were in reality paraffines melting between 55 and 60 deg. and containing up to 28 per cent acid products; the oily elements of the tars, freed of basic and acid compounds, contained neither naphthalene nor anthracene.

Below 350 deg. it contained no solid bodies; above 350 deg. paraffines were obtained; the benzols did not contain thiophene. The quantity of gas obtained was



LOW TEMPERATURE APPARATUS FOR DISTILLING COAL — TRANSVERSE SECTION

small, 17.6 liters of gas per kilogram of flaming coal from the Bismarck mine yielding 10 per cent tar.

In England some companies were formed for the distillation of coal at low temperature, among others the Coalite Company, which obtained in place of coke some coalite or semi-coke (See Génie Civil, March 14, 1918, No. 20, p. 348) which can be used as smokeless fuel, but the tar yield was very large and the coalites too friable.

Apparatus Used by German Institute

In a conference on the actual state of the coal investigations held March 6 at the General Assembly of German Iron Masters and repreduced in Stahl und Eisen, April 12 and 19, Prof. Franz Fischer, director of the institute for the study of coal, discussed at great length the distillation of coal at low temperatures and described the apparatus used for this purpose by the German Institute.

This laboratory apparatus, represented in the illustration, is composed of an iron cylinder containing the combustible, heated by a gas flame and arranged to rotate slowly around on its axis (3.5 turns). With this arrangement, the particles of coal heated by direct contact with the walls cannot be overheated, for the layer in contact with the walls is constantly being replaced. Moreover, since the particles commencing to distil are brought back to the surface, the tar vapors do not encounter the layer of coal again, but are entrained and carried out of the drum by a current of steam introduced through the hollow shaft. An electric precision thermometer serves to show the temperature of the apparatus during the operation. The apparatus is completed by a deposit chamber and a coil immersed in water.

With this apparatus, complete distillation of coal is effected in one or two hours and there is obtained with rich coal 3 per cent tar, and with flaming coal 10 per

cent tar, the composition of which is indicated in Table I.

M. Fischer says that by this method of distillation they obtained tars free from naphthalene and anthracene and containing paraffine. After the separation of the phenols, by distillation with superheated steam one can extract from the tar the lubricating oils forming 10 to 15 per cent of the weight of the coal and resembling those obtained in the treatment of coal by liquid SO_2. These lubricants, red-gold in color and possessing a pleasing odor, are mixtures of oil. They have been able to extract lubricating oils from them which ignite at 200 deg. and have, at 50 deg. temperature, a viscosity of 2 deg. to 28 deg. (Engler). The oils set down in Table I as non-viscous are oils having the character of

TABLE I—COMPOSITION OF TARS EXTRACTED BY DISTILLATION OF COAL AT LOW TEMPERATURE

Composition, Per Cent	Tar from Rich Coal	Tar from Flaming Coal
Highly viscous oils (lubricants)	15.2	10.0
Paraffines	0.4	1.0
Non-viscous oils	33.5	15.0
Phenols	14.0	50.0
Resin	4.2	1.0
Residual tar	19.2	6.0
Losses and water	13.5	17.0
Total	100.0	100.0

petrols and containing unsaturated hydrocarbons and true olefines of the formula C_nH_{2n}. They have been able to establish the fact that they polarize light weakly, which is quite characteristic of petrols.

Gases of High Calorific Value

The gases obtained during the distillation have a very high calorific value, about 9000 calories, and have a volume of 40 liters per kilogram of rich coal and of 50 liters per kilogram of flaming coal. This high calorific value is due to the presence of 70 per cent methane, ethane and heavy hydrocarbons.

They have not been able to separate the light hydrocarbons from the gases of distillation by the ordinary method; to accomplish this, they have had to distil the gases by steam after compression of 20 atmospheres in the presence of paraffine oil. They have thus obtained aromatic carbons in an amount of 0.2 to 0.3 per cent of the weight of coal boiling between 20 deg. and 100 deg. and containing almost no benzol. These hydrocarbons are a mixture of volatiles the specific gravity of which at 20 deg. is about 0.65. They yield different kinds of petroleum derivatives in distilling, such as petroleum ether, ligroin, light and heavy benzines. The tar still contains very nearly as much of these benzines, or a total of 0.3 to 0.6 per cent of the weight of coal.

These bodies, the exact chemical nature of which is not yet known but the analysis of which shows 83.5 per cent carbon and 14.5 per cent hydrogen, are more hydrogenated than benzol (7.5 per cent) and its homologs.

From the experiments made up to this time one can conclude that, if the distillation at low temperature is carefully conducted, it is possible to extract from the coal all the industrial products of petrol: paraffines, lubricants, benzines, oils.

The economic success of this distillation at low temperature depends particularly on the utilization of the coke produced. This should be obtained adequately solid; if not producers should be set up near the distilling apparatus, so that the coke can be used while still warm.

Already, thanks to the labors of Messrs. Parr and Olin at the University of Illinois, it has been possible to improve the quality of the coke obtained by mixing finely pulverized coal with the coke dust and compressing the briquet of coal during the distillation.

Chrome Sands on the Pacific Coast

By Justice F. Grugan*

In view of the extensive reports published by the U. S. Geological Survey,[1] it is not surprising that interest has been revived in the black sand deposits of the Pacific Coast, especially during the recent period when war minerals, notably chromite and platinum, were urgently sought for the Government.

Occurrences of black sand are widespread. Not only are the beaches of California and Oregon rich in natural concentrations of black sands, but many inland water courses as well. A microscopic examination of samples of these sands from many different localities reveals a certain uniformity of species and physical condition of the component mineral particles. Their proportion, however, varies to a marked degree. This variation is explained by the different conditions in the original formations from which these black sands were derived. Chromite is known to have its origin in magmatic segregation during the formative period of the peridotites and serpentines. Its subsequent liberation by erosion and decomposition, its transportation by water and the final localization of the heavier grains are processes whose occurrence is amply verified by the testimony of geological formations and the beach and river sands.

During an examination begun in June, 1918, of beaches and ancient marine deposits lying between Crescent City, California, and Bandon, Oregon (a distance of approximately 125 miles), frequent panning and magnetic tests showed that the proportions of chromite and platinum increased appreciably as the investigation proceeded northward.

Historical Notes

Fifty or sixty years ago the pioneer placer miners discovered a stratum of black sand, rich in gold values, located in the vicinity of Cut Creek, two miles back from the beach and about six miles north of what is now the City of Bandon in Coos County, Oregon. Tales of wild but prosperous communities in the old Randolph mining district are confirmed by a few desolate ruins of log cabins, partly buried by the encroaching drifts of sand. Many evidences are seen of futile attempts to win fortunes from these elusive sands. In one place, half buried, lies a complete drag bucket equipment, rusty and rotten; close by stands a large concentrating mill with strange types of zigzag riffles, screens, trommels and assay furnaces.

One beach relic of striking outline consists of a huge automobile dredge and concentrator. Great drumlike wheels of steel plate support an intricate superstructure, which houses an engine, a boiler, sluice and bump-

*Engineer, Suffern Co., N. Y.

[1] David T. Day and R. H. Richards in Mineral Resources of the U. S., 1905.

ing boxes and finally a ponderous bucket excavator driven by massive pinions, gears and sprockets. A single trial of this $20,000 machine showed that it could nose in successfully, but was unable to withdraw from the cavity so created. It should be mentioned, however, that these failures or so-called "monuments" resulted from many attempts to extract gold and platinum from the beach sands. The idea of treating ancient marine sands or "back beaches" primarily for chrome values is the outcome of war-time necessity and largely dependent upon consequent prices for success.

Origin of Cut Creek Chrome Sands

The Old Lane Mine, on the south branch of Cut Creek, was operated in the early days chiefly by underground methods and by the removal of light sand overburden. In thickness the deposit averaged six feet and underlaid several acres of ground at depths of from ten to thirty feet. The formation is probably of comparatively recent origin, as trunks of trees were sometimes encountered in the workings and displaced only with considerable difficulty and expense. The black sand was mined by pick and shovel and dumped into sluice boxes. Various devices were used to collect the gold and heavier "white metal" platinum, which, it may be stated in passing, was much despised, as it reduced the selling value of the gold, and if sold separately brought only 50c. an ounce. The rejected black sands were washed down Cut Creek and allowed to settle in a low swamp termed the "Lagoon."

The area of the "Lagoon" covered by these tailings is 2200 feet in length and from 30 feet at its narrowest limits to 220 feet at its greatest width. The surface measurement is approximately 5.8 acres, and the deposit is from one to eight feet deep. Where the soil has mixed with the sand to a depth of several inches it is covered by vegetation and a few small trees.

Character of the "Lagoon" Sands

The observer is impressed with two characteristics in studying this particular deposit. First, the average fineness of the individual grains, about 93 per cent of which will pass through a 40-mesh screen. Second, the variety of mineral constituents, chief among which, in the order of their proportionate amounts, are:

Mineral	Proportionate Per Cent.
Chromite	45
Garnet	30
Quartz and other silicates	20
Magnetite and ilmenite	3
Zircon and monazite	2
	100

This composition is not typical of Pacific Coast black sands. The percentage of chromite is unusually high and differs widely from similar appearing sands of the southern beaches which frequently contain over 50 per cent of magnetite. The individual particles are very fine and rounded but the deposit contains no slimes. The material weighs from 109 to 159 lb. per cubic foot, depending upon the variation in metallic constituents.

Tonnage and Analyses

The "Lagoon" has been carefully prospected by a series of pits at 50 foot intervals, sunk along forty-five parallel lines. A total quantity of 25,000 tons has been calculated, which averages 22.536 per cent chromic oxide, Cr_2O_3. Remarkable uniformity is shown in the results here presented:

Line	Per Cent.	Line	Per Cent.
1 Cr_2O_3	24.05	23 Cr_2O_3	24.05
2 Cr_2O_3	24.05	24 Cr_2O_3	24.06
3 Cr_2O_3	22.2	25 Cr_2O_3	24.5
4 Cr_2O_3	23.05	26 Cr_2O_3	21.8
5 Cr_2O_3	21.8	27 Cr_2O_3	23.0
6 Cr_2O_3	22.2	28 Cr_2O_3	18.6
7 Cr_2O_3	20.5	29 Cr_2O_3	21.8
8 Cr_2O_3	21.4	30 Cr_2O_3	19.5
9 Cr_2O_3	26.5	31 Cr_2O_3	14.1
10 Cr_2O_3	23.05	32 Cr_2O_3	20.4
11 Cr_2O_3	24.1	33 Cr_2O_3	21.8
12 Cr_2O_3	23.9	34 Cr_2O_3	21.8
13 Cr_2O_3	23.8	35 Cr_2O_3	23.8
14 Cr_2O_3	24.1	36 Cr_2O_3	19.5
15 Cr_2O_3	23.6	37 Cr_2O_3	22.6
16 Cr_2O_3	22.8	38 Cr_2O_3	23.1
17 Cr_2O_3	22.5	39 Cr_2O_3	24.05
18 Cr_2O_3	24.05	40 Cr_2O_3	22.5
19 Cr_2O_3	16.02	41 Cr_2O_3	22.1
20 Cr_2O_3	20.9	42 Cr_2O_3	26.0
21 Cr_2O_3	22.0	43 Cr_2O_3	23.0
22 Cr_2O_3	24.5	44 Cr_2O_3	21.1
		45 Cr_2O_3	29.8

Metallurgical Tests

Test runs on representative samples of these sands have been made at San Francisco, Denver and Seattle. A comparison of results indicates a recovery of from 70 to 75 per cent of the Cr_2O_3 contained in the original sands, in the form of a chromite concentrate averaging 40.45 per cent Cr_2O_3.

The San Francisco test was a table concentration at the laboratory of Hamilton, Beauchamp and Woodworth; Electromagnetic concentration at laboratory of University of California, Berkeley, California.

The sample was screened through a 40-mesh screen, the oversize being rejected. The material which passed through this screen was run on a Deister-Overstrom table, making two products—a tailing, which was rejected, and a rough concentrate. This rough concentrate was retabled, producing a middling and a finished table concentrate. The middling product was reserved for further treatment. The finished table concentrate was dried and run over a Wetherill magnetic separator, producing the final products of this test.

The Denver test was at the testing laboratory of Henry E. Wood.

The sample was screened through a 20-mesh screen, the oversize being rejected. The undersize was further screened through a 40-mesh screen, the oversize from this being likewise rejected. The 40-mesh material was run on a Wilfley table producing a tailing product, which was rejected, and a concentrate which was further treated on a Wetherill electro-magnetic separator.

The products from poles 1 and 2 were mixed to form the magnetite product, and 3 and 4 to form the garnet product. Pole 5 produced the chromite concentrate which analyzed as follows:

	Per Cent.
Cr_2O_3	41.35
SiO_2	4.10
Al_2O_3	13.05
FeO	24.58
Mn	1.64
Sulphur	0.81
TiO_2	Trace

Pole 6 gave a product consisting of a yellow sand (monazite) and chromite. The non-magnetic reject was further treated on a Wilfley table, producing thereby a tailing which was rejected and a concentrate consisting of zircon. Recovery of the chromite was shown to be 77.44 per cent.

The Seattle test was at the Laboratory of the U. S. Bureau of Mines experiment station.

The material was run over a half-size Deister-Overstrom concentrating table, forming three products—concentrate, middling and tailing. The concentrate and middling were run separately over Dings magnetic separators, forming in each case concentrate, middling, magnetite and sand products. The respective products from the two separations were of approximately the same grades, so were brought together, forming the final products of chromite, concentrate, middling, magnetite and sand. To this last (sand) was added the tailing product from the Deister-Overstrom table separation.

Proposed Method of Treatment

Based on the results of the foregoing tests, it is planned first to screen the sands and reject the 40-mesh oversize. The undersize will be concentrated on Deister-Overstrom tables, dried and then passed over a 3-magnet, six-pole Wetherill magnetic separator. The non-magnetic reject from the separator may be retabled and the zircon recovered.

Rejection of the 40-mesh oversize will, at the very beginning of the treatment, throw out about 8 per cent of the sands, without loss of valuable contents. Treatment on the Deister-Overstrom tables will further reduce the amount of material for magnetic separation. The concentrate leaving the table will be approximately 75 per cent, by weight, of the original sands and will contain 95 per cent of the chromite. The Wetherill magnetic separator treating the concentrate will recover over 75 per cent of the chromite. These chromite concentrates have been tested by the Huff Electrostatic Separator Co., and preliminary reports show that the grade can be improved to 46 per cent Cr_2O_3 or better.

The other products from the Wetherill separator will be magnetite, garnet and zircon (in the tailings).

Production

Since the total tonnage in the "Lagoon" is 25,000 tons, and a conservative estimate of the average Cr_2O_3 content is 20 per cent, a total of 5000 tons of Cr_2O_3 is obtained. Allowing 15 per cent loss in mining leaves 4250 tons and assuming a recovery of 70 per cent in milling, the amount is reduced to 2975 tons of Cr_2O_3. This is equivalent to 7437 tons of chromite concentrates averaging 40 per cent Cr_2O_3. There will also be about 4800 tons of garnet, 460 tons of magnetite and 288 tons of zircon produced. These chromite concentrates are particularly suited to the chemical trade, although the tenor of chromic oxide is not as high as in the imported ores. The rate of production should be from 300 tons to 400 tons monthly.

Unstable Conditions Delay Operations

Operations have been delayed owing to the unstable conditions affecting the chrome ore market. The lessee received direct encouragement from Government bureaus until very recently, when all support was withdrawn and the problem of finding a market for the product became the most important factor in the enterprise. Apparently the Government admits its moral obligation to protect domestic chrome ore producers who are left "holding the bag," but as yet no constructive action or policy is forthcoming.

Canadian Graphite Industry

HUGH S. SPENCE presents a short paper on "Canadian Graphite" in the recently issued Summary Report of the Mines Branch of the Canadian Department of Mines, 1917. He notes that the producing deposits occur in the Provinces of Ontario and Quebec within a radius of 150 miles of Ottawa. In spite of the great demand, but three companies operated at all steadily; nine others, each equipped with a mill, have been completely idle or in only intermittent operation.

The flake graphite occurs in disseminated form either in crystalline limestone or in calcareous bands intercalated in gneiss. Both varieties of ore have been treated by essentially similar concentration methods. These are, briefly, drying in wood-fired kilns, reducing in gyratory crushers followed by two or more sets of heavy rolls, and subsequent alternate screening and crushing in rolls of the flour-mill type. Each set of rolls eliminates gangue by reducing the brittle calcite and silicates to powder, while the soft graphite tends to flatten out and is caught by the screens. The product from the final set of rolls is sometimes polished between burr-stones or goes to an electrostatic machine, which removes any remaining impurities, particularly mica; the latter is one of the most difficult minerals to eliminate, owing to its softness and consequent resistance to crushing.

In the early days of the graphite industry, a wet process of concentration, employing buddles, was practiced. This method is still in use at one mill, as the initial step in concentration, followed by drying, the dried product then proceeding to rolls and screens.

While certain of the mills achieve a fair recovery of the graphite contained in the ore treated, the majority lose an undue percentage in the tailings. The concentration methods in general use are far from being efficient. In addition to poor recovery, the carbon content of the best, or No. 1, product is seldom brought over 90 per cent, and is generally lower; a great deal of the flake in the rock is broken up in the milling, and goes into the finer No. 2 product and to the No. 3, or dust. The large amount of dust produced in the mill in grinding the kiln-dried ore is very objectionable. Screen tests on samples of No. 1 flake from seven mills showed the mean percentages of different size flake composing this grade to be as follows:

	Per Cent
+ 20 mesh	1 7
+ 40 mesh	18 5
+ 60 mesh	67 0
+ 80 mesh	8. 0
+100 mesh	1 1
—100 mesh	2. 9

Most mills produce three grades of graphite, known as No. 1 flake, No. 2 flake and dust. The No. 1 flake goes principally to the crucible trade; No. 2 is employed in lubricating products; and No. 3, or dust, is used in foundry work.

The graphite particles employed in crucible manufacture are required to be of a certain size in order to bind efficiently with the clay. In this connection it may be noted that one of the reasons for the preference for Ceylon graphite for use in the manufacture of crucibles is that this variety does not occur in thin flakes like the American graphite, but is more massively crystalline and breaks up on crushing into more angular fragments, hence it requires less clay as a binder.

Minor Occurrences of Mercury in Europe

Comments on the Minor Quicksilver Operations in Austria, Italy, Spain and Mediterranean Countries—Mercurial Poisoning Cases Are Numerous, Due to a General Lack of Sanitary Precautions—Hygienic Measures Being Introduced at Idria

BY DR. ROLAND STERNER-RAINER[1]

IN ADDITION to the great mines at Almaden, Spain also possesses productive quicksilver deposits in the Asturian province of Oviedo, in Bajodez (Estremadura) and Granada (Andalusia), while the many others, even those of La Creu, have no commercial importance. To complete the list of mercury deposits the following must be mentioned, even though they are only of geological or mineralogical interest: Andra (Santander), in Teruel, Gargantiel (Ciudad Real) Torbiscon (Granada), Cartagena (Murcia), as also Purchena and Cuevas de Vera (Almeria).

Mieres, the center of the Asturian mining industry, (the quicksilver mines of the "Union Asturiana" and "El Provenir" or "Pena y Esperanza de Mieres" are situated here) lies on the railroad from Oviedo to Leon. These deposits, which at present are exploited in 24 mines, were worked by the Romans, but have been re-opened only since 1840. The ores are impregnations of cinnabar with a little metacinnabar, amalgam, orpiment and realgar, in the carboniferous breccias and quartzites.

The output, which in 1911 was 4699 tons of ore having an average content of 0.7 per cent, is treated in seven retorts, seven "Gascue-Rodriguez"[2] furnaces, and four of the old type of Idrian furnaces. Fifteen tons of mercury (formerly 50 to 80 tons) were produced. The impregnations found along this same railroad south of the Cordillera Cantabrica at Pola de Lena and Limares, and at the Rio Muno, are not of commercial importance.

The ores of Usagre Bienvenida in Bajadoz province (on the railroad from Merida via Zafra to Sevilla) are richer than those of Mieres. Here the cinnabar is associated with sulphide of copper ores, spathic iron and manganous carbonate, in quartz veins in the crystalline limestones of the Cambrian. This limestone also shows occasional cinnabar impregnations. Despite the fact that these deposits have been opened only a few years and that one of the new mines has doubled its former production of 1000 tons of ore per annum so that the future operation of these mines seems sure, two new Bustamente furnaces may be admired in full operation. The ore content, formerly 1.24 per cent, has increased, this fact explaining the relatively high output of 40 tons of mercury. Ores from the "Alpujarra," on the south slope of the Sierra Nevada, show a content of 0.7 to 2 per cent mercury. The mercury is contained in iron oxide incrustations of calcite; in certain places this oxide is so plentiful that two Bustamente furnaces were erected to treat it. In Valencia, all efforts to treat the ore profitably have failed; this ore consists of an intimate mixture of cinnabar, quartz and carbonate as vein fillings in the sandstone.

Even Portugal, which possesses no deposits of note, has produced small quantities of mercury during the last few years. The unexpected increase in production of the mines on the Appenine peninsula is due solely to the mines of Southern Toskana, at Siena Grosseto. The operations at Vallata, in the Province Belluno, have been abandoned for four years, while those of Levigliani and Ripa, in the Province Lucca, and those of Jano have been abandoned for 50 years.

Practically all the Italian production is from the region near Monte Amiata, and the operations of the live properties have been already described[3]. The mercury occurrences at Arcaja (Lucca), Monte delle Fate (Pisa), Monte Loreto (Gonova), San Quirico di Albaceto (Parma), Margna (Como) and San Donata (Cosenza) are of interest mineralogically, but are not exploited. The fine dust of lead smelter at Monteponi, Sardinia, yields a few hundred kilograms per annum.

Small Austrian and Hungarian Deposits

Austria possesses an even greater number of quicksilver occurrences than Italy, but here also the metal is found in quantity only at one locality. Idria, alone, is responsible for the country's production, all other mines being closed or never having been worked for cinnabar ores alone. Twenty years ago the plant of Littai in Krain was abandoned, which only shortly before had been producing 20 metric tons of mercury, and ten years later the neighboring plant of St. Anna, which was a rival of Littai in the '90s, followed suit. Sagron, in southeast Tyrol, which was exploiting the same ore body as the Italian Vallalta Company, has abandoned its mine and reduction plant since 1907. The best of the Dellach mines—Reichenau and Kotschna—as also that of the Buchholz mines near Paternion, have been abandoned for 60 or 70 years.

Since the decline of Russia's production[4] the only other European country producing quicksilver was Hungary, which produced about 80 tons. There are quite a number of quicksilver occurrences in Hungary, but at present the entire production comes from the Kotterbach plant in upper Hungary, where fahl ores are being treated. The Kotterbach mines also carry spathic and brown iron ore, through which small amounts of fahl ore are disseminated. The fumes formed in calcining these brown iron ores are passed into the bottom of limestone-filled, water-sprayed, wood condensers. Mercury, arsenic and antimony compounds and ore dust

[1] Österreichische Zeitschrift, für Berg- und Hüttenwesen. Vol. 62, 1914, p. 529. Translated in connection with a co-operative investigation of the metallurgy of mercury being carried on by the United States Bureau of Mines and the New Idria Quicksilver Mining Company. C. N. Schuette, Metallurgical Assistant, Bureau of Mines, Translator.

[2] *Eng. and Min. Journ.*, 1889, Vol. 48, No. 20; 1898, Vol. 62, No. 7; *Rev. Univers. de Mines*, 1896, 32, 233; Mineral Industry 4, 524.

[3] *Chemical and Metallurgical Engineering*, Vol. 19, p. 770.

[4] Since new ore bodies have been found in Nikitowka, the plant is being rebuilt.

are condensed to a slime carrying about 25 to 30 per cent mercury. This slime is filtered through coke, is washed and dried, and together with fahl ore, constitutes a charge containing 1.5 to 2 per cent mercury for two fine-ore furnaces. The rich soot of the furnace flues is pressed in the same manner as the furnace soot caught in the Cermak condensers, and the soot rejects are again charged to the fine-ore furnaces.

The quicksilver mine of Zalatna in Siebenbürgen is no longer productive, and the entire production of Hungary amounts to only 80 tons of mercury per annum.

There are several quicksilver prospects in Bosnia. Bosnic-Idria and Maschkara, however, are the only two that have produced any quicksilver (by a process resembling medieval metallurgy). To-day the developed ore bodies of these mines have been worked out. The promising quicksilver prospect of Avala which was discovered while grading for a railroad at a point about 25 km. south of Belgrade has also been worked out.

Deposits in Other Mediterranean Countries

Since none of the other European countries produce quicksilver—Prussia produces a few tons per annum from fine dust and lead chamber slime—there remain only the Mediterranean countries Algeria and Asia Minor to speak about. Even though these countries do not belong to Europe, they are closely related to it, both in historical development and economic relations. The Taghit mine, situated about 35 km. from the Algerian city of Batna, was one of the first to erect Cermak-Spirek fine-ore furnaces to treat their mixed ore, zinc blende and argentiferous galena containing cinnabar. Spirek also modified the coarse-ore shaft furnaces and the lead-treating reverberatory furnaces, so that they serve not only to roast the ores, but are at the same time adapted to the recovery of mercury.

Noticeable competition may soon be expected from the young mines of Asia Minor. The Anatolian ores found in a dry, high country not far from Koniah[5] were worked by the ancient Phrygians more than 3000 years ago. The knowledge of these prospects was lost in later times until the cinnabar was re-discovered by the chance find of a shepherd boy.

The ores are associated with local silicifications in the limestone, these silicifications being of contemporaneous deposition with the cinnabar. More than 13,000 tons of 1 per cent ore had been developed in these mines as long as five years ago. To furnace these ores the 15-ton Spirek shaft furnace and an 8-ton fine-ore furnace were erected.

Near the coast at Kara Burnu, about 30 km. south of Smyrna, large bodies of cinnabar-impregnated quartzites are found so near the surface that they can easily be mined by surface methods. The average ore mined during the first year of active mining operations ran 0.75 to 1 per cent mercury. The metallurgical plant consists of two Spirek shaft furnaces for lump ore and one fine-ore furnace. The capacity of the plant is 40 tons of ore per day, and the monthly production was 250 to 275 flasks of mercury.

One question always asked when quicksilver mining is mentioned is: "What influence does the reduction of mercury ores, the frequent contact with metallic mercury and the inhalation of the fumes of this metal exercise upon the human organism? What influence has this effect on the health of the workmen engaged in producing this metal, and to what degree has it been possible to eliminate or counteract these detrimental effects by improving the metallurgical practice and by social welfare work?"

The extensive literature on the subject of mercurial poisoning[6] shows that the symptoms of this poisoning are a swelling of the gums, a reddening and infection of the mucous membrane and the throat, excessive saliva flow and disorder of the digestive organs. Together with these ailments, the sick person experiences a dull feeling and exhibits a peculiar timidity which prevents him from working quietly while being watched. If the work around a quicksilver plant is not given up the infection of the mucous membrane develops ulcers in the mouth and causes a swelling of the saliva and lymphatic glands. The muscular control is also affected, resulting in a curious shaking of the body called tremor mercurialis, which may become so severe that those affected die from the fatigue it causes. The human organism when weakened from this disease is very apt to contract tuberculosis.

Mercurial Poisoning Frequent at Almaden

As might be surmised from the description of the conditions at Almaden, the cases of mercurial poisoning at this plant are very numerous. Not only the men in the reduction plant are exposed to this poisoning but also the miners in the poorly ventilated mines; this mercury vapor in the mines is due to the plentiful sprinkling of metallic mercury in the ore. If the number of fatalities at the plant is not large, this is because it is closed for about six months, in which time the workmen have opportunity partially to regain their health in the clear air of this elevated region. Even though the workmen three years ago appealed to the Government for a betterment of the hygienic conditions at the plant, and though professional men affirmed the itemized evils, little has been changed.[7]

The number of patients is still very great; even serious cases, such as "calambres," tremor, paralysis and ulcers which attack first the gums and then the jawbone are not rare. Wash bowls and baths are unknown at the plant. As noted, the miners are no less subject to mercurial poisoning than the reduction plant men, even though the latter are furnished with clothes made of a smooth material which are cleaned on company account. This is the sum total of the social welfare work, as there are no competent laws for the protection of workingmen and there is no inspector looking after the execution of such laws.

Tuscanian Conditions Better

The hygienic conditions in the Tuscanian works are very much better. The ore of the entire district contains no trace of free mercury, so that mercurial poisoning is not possible in the mining and drying of the ores.

[5] F. F. Sharpless, *Eng. and Min. Journ.*, LXXXVI, 1908, September, p. 501; *The Mining Industry*, 1908, Vol. XVII, p. 746; *Rassegna Mineraria*, 1908, April 11.

[6] A. Kussmaul, Untersuchungen über den konstitutionellen Merkulialismus und sein Verhältnis zur konstitutionellen Syphilis, Würsburg, 1861; Letuelle, Essai sur l'hydrargyrisme profesionel, Revue d'hygiene 1859; Ludwig Teleky, Die gewerbliche Quecksilbervergiftung, Berlin, 1912.

[7] R. Velaz and José de Udeba: Informe sobre las minas de Almaden.

The individual plants are generally smaller, and because of the mild Italian climate, are airily built, assuring a frequent change of atmosphere in the buildings. The Abbadia San Salvatore plant, which was built only last year, incorporated hygienic principles in its construction and has numerous provisions for safeguarding the health of its workmen, only 25 per cent of whom are exposed to fume. Even so, as has been stated by C. D. Castro, not only are those exposed workmen subject to this occupational disease, but in time even those men who only handle the metallic mercury become sick. Careful instruction of the furnacemen would, no doubt, eliminate one source of the mercurial poisoning, but despite the most careful supervision by competent foremen, it was impossible to eliminate the carelessness of the workingmen. The clean-up, the treatment of the soot and the bottling of the mercury will always be dangerous as long as the present method of manipulation obtains, and the danger can only be minimized by the exercise of great caution on the part of all concerned.

Respirators which Tarngi[5] constructed of thin layers of aluminium netting were not successful at Abbadia San Salvatore, as this metal easily forms an amalgam with incidental tumifaction and development of heat. Frequent interchange of the men between the mines, reduction plant and outside working places is a beneficial, but not strictly adhered to, policy. Suitable working clothes, hot baths and frequent medical examinations, which are compulsory at Abbadia San Salvatore, prevent the development of serious cases of mercurial poisoning, and the occupational disease statistics of the plant are very encouraging since 1910.

Work in Idrian Mines Not Dangerous

The work in the Idrian mines, in which metallic mercury is found along with cinnabar, is not dangerous, as shown by statistics. The policy of changing the men who work in the stopes is strictly adhered to and adequate ventilation is obtained by improved methods. Light cases of sickness still occur, because the sense of cleanliness is but little developed in the workmen, and they do not make sufficient use of the bathing facilities provided at the plant. The change of workmen in the reduction plant, which has been reintroduced since 1897, has also bettered the conditions of health. Since the beginning of this century the amount of sickness has been further reduced by the technical improvements of the plant, and is now at the lowest known figure. Each workman is furnished with large rations of fat (as the eating of fat is thought to be beneficial), is furnished with suitable working clothes and enjoys an annual vacation of two weeks at full pay.

Light cases of poisoning are easily cured by a longer stay in a region of pure air. The introduction of producer-gas furnaces is a further step toward the fulfillment of hygienic requirements, as the soot production is less and consequently the work of the clean-up and of the soot treatment could be reduced appreciably. Kroupa's new shaft furnace will be a further step in this direction, as will the mechanical disposal of the furnace tailings, the improved condensers, the covered soot presses and the proposed new stack, all of which combine economical with hygienic advantages, and assure to Idria its position as the model quicksilver plant.

[5]Gazz. chim. ital. 34, II, p. 436.

Lately bathing facilities have been provided at the reduction plant also, and if occasional cases of sickness still occur, this will not be the fault of the health regulations of the plant, but will be due to the lack of good will on part of the workmen who carry out their assigned tasks without the proper sense of responsibility, neglect to use the shower baths, do not change their clothes, and by living in closed hot rooms allow the mercury of their clothes to vaporize. No amount of technical improvements or health regulations can change this; only a competent education of the workmen and their families for a period of many years can effect a complete remedy.

Engineering Research in Chemical Organizations

By Crosby Field

During the past four years the chemical industry in this country has been very rapidly advancing, having met with little opposition, but now, with the return of peace conditions, there is apparent the necessity for reorganizing to meet extremely intense competition, or as it may be called, "consolidating the positions in order to withstand heavy counter-attacks."

The parts to be played in this readjustment by finance, trade, commerce, export and other similar functions have been frequently discussed, and it is believed are now quite well understood, hence will not be mentioned further herein. There is one very useful "arm of the service," however, that it is believed is not quite so well understood, and it is the purpose of this article to invite attention to its activities and importance. For want of a more precise title, this function may be called "Engineering Research."

In any chemical organization there should be, of course, one research department, under the head of one man, who will be termed for the purpose of this article the manager of the research department. This department is divided into two branches, chemical and engineering, each under one man, who for the purpose of this article will be called a director; so that there should be a director of chemical research and a director of engineering research.

The functions of the director of chemical research are so well understood by the members of the chemical industry that further mention may be omitted and the remainder of this space devoted to a brief summary of the functions of the director of engineering research.

The director of engineering research has five principal functions to perform, which may be modified according to the particular organization in mind. These are (1) experimental, (2) compilation of engineering data, (3) standardization of layout and apparatus, (4) education and (5) liaison.

The experimental work necessary arises from two different causes, which, however, are interlocking, hence usually the same work produces both classes of results desired. These classes are the adaptation of chemical processes to factory conditions and the development of special chemical machinery.

The chemist usually develops his process in the chemical laboratory, using grams of chemicals in glass apparatus, dealing only superficially with the physical characteristics of the intermediates and of the final

product and neglecting all matters concerning the quantities of energy required and the best method of transmission thereof. The process is then put into the factory using hundreds or even thousands of pounds instead of grams and metal or wooden apparatus instead of glass, when the physical characteristics of the products and of their containers become vital, the impurities collected in the process assume greater importance, and the economy of the process frequently depends upon the method of supply and transmission of the energy required. It is because of such conditions that processes seemingly good in the laboratory fail in the factory; and conversely, processes which appear good in the laboratory, but which involve many questions to which the factory answers are not known, fail to be tried out in the factory because of the heavy expense at stake.

The general answer to the above situation is a function of the director of engineering research, and to accomplish his object he has an engineering or factory laboratory. This is a building equipped with small apparatus similar in all respects to the apparatus which is standard in the factory and of such size as to give accurately the necessary physical constants. This will generally be found to require units having a capacity of several gallons, or about one hundred pounds. The interior of the building will generally be without permanent structures, with the exception of a number of columns, to which beams may be quickly clamped, so as to facilitate the setting up and the tearing down of apparatus.

Will Adapt Chemical Process to the Laboratory

Within this laboratory will be accomplished the adaptation of the chemical process to the factory. The chemist will turn over the complete results of his experiments with grams of material within glass tubes to the director of engineering research, who in this laboratory will determine the proper apparatus to be used, and in connection with the director of manufacturing, the approximate sizes thereof. He will be responsible for deciding the material of which the apparatus shall be made, whether direct fire, steam or oil will be used for heating, the utilization of waste gases. limits of and methods of engineering control, etc. In some organizations he will be responsible for designing the plant, but if not he is to turn over to the design engineer the necessary data and the proper recommendations for types of apparatus.

In order to accomplish the above it is necessary that he perform well his second function, that of collection of engineering data. To do this he may either utilize the factory organizations or send agents to run special tests, or both. He must have available, however, not only the basic facts regarding each type of machinery present in the plant or advertised on the market, but also operating records of cost, including maintenance and consumption of power, in so far as possible. This should apply not only to the process apparatus in the plant, that is to say, what is more generally called the chemical machinery, but also the plant machinery, by which is meant all that directly connected with the power plant, including boilers, engines, refrigerators, gas producers, compressors and vacuum pumps, pumps, elevators and conveying machinery, etc. Having collected these data, the third function, that of standardization of machinery, follows as a matter of course.

In all these three functionings situations will arise which indicate the necessity or desirability of a new type of special chemical machinery, which should then be developed in the engineering laboratory. It is thought that this will become very important in the near future, as a stabilizing of the chemical industry throughout the world will tend to establish standard chemical processes, after the establishment of which manufacturing success will depend in greater degree upon the development and adoption of special machinery.

Function of Education Frequently Overlooked

The fourth function, education, is a matter frequently overlooked. The training of the necessary personnel for a new industry is always hard, but is vital to the success of that industry. It is essential that it be recognized as a necessary function, and its place included in the several branches of the organization where opportunity is afforded for its performance.

The director of engineering research should, therefore, publish to a selected list of trustworthy employees such of his accumulated data as would appear desirable. This can well be done by means of a mimeographed periodical, which should be kept up to the minute by containing the results of the latest tests, especially acceptance tests on new installations. He should also provide for lectures and the other well-recognized methods of disseminating information, but by far his greatest opportunity lies in his laboratory during the time that a chemical process is being adapted to the factory. The operating foreman-to-be and his principal assistants should be present during the experiments, and this small unit production should be continued for a while under the actual operation of these men, directed by the engineering laboratory specialist in charge.

The fifth function, liaison, is the most difficult to perform satisfactorily, and will be the one, in the last analysis, which will cause the director to succeed or to fail. Close touch must be had with all departments and with all plants, and this contact must be maintained in spite of the many pet theories and frequently crotchety characters of the various executives and men concerned. The director must so limit his activities to the strictly engineering and advisory sides that in his dealings with the chemist, particularly while the process is still in the chemical laboratory, the latter will have no suspicion of his motives and will render him full information and his further co-operation during the period the process is in the engineering laboratory. Many good suggestions will be forthcoming from men in the plants, and a system should be arranged for giving recognition to the individual.

In short, there is present to-day in each chemical company of any considerable size the necessity for a director of engineering research, who must perform his major functions of engineering experiments, compilation of engineering data, standardization of layout and apparatus, education and liaison with energy and tact. He should, furthermore, be a man of considerable executive ability, engineering experience and knowledge of chemistry, and should, moreover, have linked with those no small degree of inventive talent.

Roasting Flotation Concentrates.—CHARLES H. FULTON of Cleveland, Ohio, patents a process of roasting fine flotation concentrates by burning them in heated air somewhat similar to the way pulverized fuel is consumed. Fig. 1 shows an approved system of apparatus. The inventor notes the difficulties of proper desulphurization of fine concentrators in mechanically rabbled hearth roasters. In case the concentrates are roasted

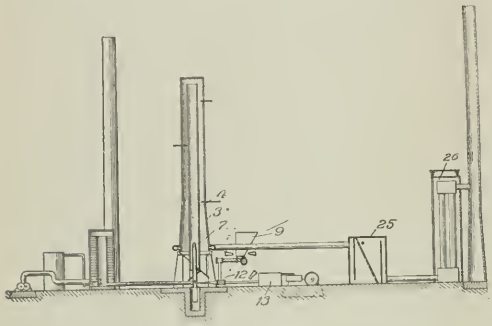


FIG. 1. APPARATUS FOR ROASTING FLOTATION CONCENTRATES

in a current of hot gases of combustion, the coarser particles fall out of suspension partially oxidized, while the fine particles are carried along in suspension in gases too cool for proper reaction. In Fig. 1 preheated ore is supplied from hopper 9 to casting 12, where the proper amount of compressed air from receiver 13 is mixed with it to hold the particles in suspension pending their delivery through injector nozzle 7. At this point it meets low pressure air heated in the gas-producer-stove system illustrated to the left, the various temperatures being so regulated that ignition takes place immediately. The temperature of the preheated air of combustion evidently depends upon the temperature of the ore, the length of the furnace in which complete combustion is to be effected, and the calorific power of the fuel. The burned ore travels up the inner stack 4 and down the outer annular portion 3, the bulk of it being deposited in the hoppers at the bottom of the vertical shaft. Fine dust is caught in the chamber 25 and the electrostatic precipitator 26. If the minimum air for proper roasting is introduced at the ore burner the resulting gas will be very high in sulphur dioxide and may be utilized in the manufacture of sulphuric acid. (1,273,844; assigned to Metallurgical Laboratories, Inc.; July 30, 1918.)

Smelting Copper-Nickel Pyrrhotite.—W. MCA. JOHNSON of Hartford, Conn., patents the following process of smelting copper-nickel pyrrhotites so that a separation of the valuable constituents may be made. Such an ore may contain 2 per cent copper, 4 per cent nickel, 45 per cent iron, 38 per cent sulphur, and 0.10 oz. gold, silver, platinum and palladium. This ore is roasted, smelted in the blast furnace and converted into a matte containing 52 per cent nickel, 26 per cent copper, and 1 per cent iron in well-known machines and in the usual manner. The resulting matte is cupola-melted with 45 per cent crude Na_2SO_4, a large excess of coke and a strongly reducing atmosphere. The sodium sulphate is reduced to the sulphide, which dissolves copper sulphide more readily than nickel, and the result is a regulus containing "tops" rich in copper and "bottoms" rich in nickel. The process is repeated two or three times, when the tops are finally low in nickel and the bottom low in copper, and contain 95 per cent Ni_2S, 2 per cent Na_2S, 1.5 per cent Cu_2S, 1 per cent Co_2S and 0.5 per cent FeS. The bottoms are then granulated and treated with chlorine gas at 250 deg. C., converting the sulphides to chlorides and volatilizing the sulphur as SCl_2. Water leaching will now remove the soluble sulphides, leaving a residue which may be smelted for silver. All metals but nickel, iron and cobalt may now be removed by electrolysis, precipitation by H_2S in acid solution, or cementation on nickel or iron. The latter is preferred, and gives a precipitate of copper, platinum and palladium which is readily separated by known methods. From the nickel-iron-cobalt solution the two latter may be precipitated by bleaching powder and Na_2CO_3, the resulting hydrates being filtered and separated by redissolving and reprecipitating the iron by a quantitative amount of the same reagents. The nickel chloride solution is now contaminated by sodium chloride only, and is evaporated to dryness, fused, and when at a red heat steam and pulverized coal are introduced into the bath. The nickel is then reduced according to the equation

$$NiCl_2 + H_2 = Ni + 2HCl$$

and melted to ingot form in an open hearth furnace. (1,238,298; assigned to the Continuous Zinc Furnace Co.; Aug. 28, 1917.)

Potash From Silicates.—GUY STERLING of Salt Lake City, Utah, notes that a heated mixture of potassium bearing silicates and sodium sulphate will produce but little soluble potash unless the amount of sodium salt is largely in excess. High temperature will volatilize some of the potash, but vitrifies the residue so that the remainder of the potassium cannot be extracted by lixiviation. If, however, a mixture of approximately three parts of feldspar, two parts of limestone and one part of sodium sulphate or chloride is heated with stirring at about 800 deg. C., the potassium in the silicate is displaced in part by the sodium and in part by the calcium oxide, and the potassium sulphate formed by the reaction volatilizes and escapes with the CO_2 formed by the simultaneous decomposition of the limestone. Thus the limestone is usable as a chemical reagent, as a preventive of vitrification, and its liberated gas is a vehicle for the escape of the volatile potash salts. (1,268,508; June 4, 1918.)

Reducing Reagent.—CHARLES S. BRADLEY of New York City heats burned lime with pyrite to a low red heat, when the following reaction will proceed to within 10 per cent of completion:

$$4FeS_2 + 4CaO = 4FeS + 3CaS + CaSO_4$$

This mixture may be used as such for the reduction of ferric or cupric salts, the reaction going forward strongly in hot solutions:

$$14CuCl_2 + 4FeS + 3CaS = 7Cu_2Cl_2 + 4FeCl_2 + 3CaCl_2 + 7S$$

Similarly for ferric chloride. The calcium chloride is of value as a solvent, while any copper sulphide contained in the original pyrite not only aids the reaction but goes into solution and is recovered at the same time. (1,253,775; Jan. 15, 1918.)

Recent Chemical and Metallurgical Patents

Alumina for Refractories and Abrasives

Crystalline Fused Alumina.—F. J. TONE of Niagara Falls patents a process of treating ores of alumina containing alkali, such as alunite, so as to recover the alumina in fused crystalline form and the alkali in water-soluble compounds. He charges the ore into an electric arc furnace of the depending electrode type, such as he patented in No. 929,517, and heats it to a temperature in excess of 2100 deg. C. This drives off all the moisture, sulphur and potassium of the alunite without forming any double silicates of potassium and aluminium which result from low-temperature calcination. The fume may be caught in well-known apparatus. The crystalline product remaining in the furnace is free from potash, and should contain from 95 to 99 per cent alumina. In case the ore contains more iron and silica than will permit of a product of this required purity, the impurities may be reduced to a 20 per cent ferrosilicon during the process of fusion by the addition of the required iron and reducing elements. (1,239,984; assigned to the Carborundum Co.; Sept. 11, 1917.)

Beta-alumina.—L. E. SAUNDERS and R. H. WHITE of Niagara Falls note that small amounts of beta-alumina have been noted in certain furnace products. It is so termed to differentiate it from alpha-alumina, occurring naturally as corundum, sapphire, ruby, etc., the two forms being distinguished by the lower refractive index, higher double refraction and lower specific gravity of the beta modification. It also has a characteristic platy, hexagonal crystalline habit, and is hard but relatively weak. It has special applications for abrasives which polish without leaving scratches. If substantially pure amorphous alumina be heated with somewhat more than five per cent of Na_2O as alkaline carbonate, the resulting pig will be found to contain from 70 to 85 per cent of the alumina in the beta modification. The alkaline compound must be chosen which will not be largely volatilized during the heating, since the alkaline oxide is probably the converting agent. The inventors think that the alkali additions yield a product of high boiling point which exists as vapor at the moment of solidification of the alumina, as evidenced by the cellular appearance of portions of the resulting pig. The effect of the alkali additions is seriously interfered with by SiO_2 and TiO_2, and the raw materials must be substantially free from these harmful compounds. (1,263,708; assigned to Norton Co.; Apr. 23, 1918.)

Alumina from Impure Bauxite.—In case an impure bauxite containing after calcination about 4 per cent SiO_2, 7 per cent Fe_2O_3 and 3.5 per cent TiO_2 is melted in a furnace such as patented in re-issue No. 13,027 with 2 to 3 per cent Na_2O, a dark gray, fine-grained product is produced. Messrs. SAUNDERS and WHITE find that this product has a weak grain desirable for certain purposes. Carbon may be introduced before furnacing, which will produce material lighter in color, and with a smaller amount of the original and added impurities. In either case will any considerable amounts of beta-aluminium be formed. (1,263,709 and 1,263,-710; asigned to Norton Co.; Apr. 23, 1918.)

Purifying Alumina.—If impure bauxite be heated with carbon in an electric furnace with an idea of forming crystalline material for refractories or abrasives, considerable alumina is reduced if the amount of carbon added approaches the theoretical quantity required to reduce the impurities. The tendency to form reduction products from the carbon of the furnace electrodes or bottom is very pronounced in fusing even the purest alumina, since the easily reducible oxides of iron and silica existing as normal impurities protect the alumina to a certain extent. L. E. SAUNDERS and R. H. WHITE of Niagara Falls have discovered that the reduced alumina, consisting of undesirable carbides and hypothetical sub-oxides which disintegrate when exposed to moisture, may be preserved from disintegration by adding to the furnace charge an appropriate amount of sodium or zinc compounds (from 1 to 5 per cent) and any excess of which volatilizes from the fused mass. The formation of undesirable weak, porous grains of alumina from these oxidizing additions may be obviated, together with a substantial absence of reduced aluminium compounds, by adding from 10 to 20 per cent of iron to the furnace charge. The molten iron absorbs the excess carbon and the reduced impurities and does not react with the fused alumina. Another method of refining alumina containing carbides is to mix it with impure bauxite similar to that forming the original charge. The quantity of impure material used should be such that the reduced aluminium compounds will react quantitatively with the iron, silicon and other oxides on a second heating. This method is particularly good, since it is believed that the reduction products of alumina are the effective reducing agents for the elimination of the last traces of non-aluminous oxides. (1,269,141, 1,269,222, 1,269,223 and 1,269,224; assigned to Norton Co.; June 11, 1918.)

Production of Magnesium.—G. O. SEWARD of Jersey City, N. J., patents an improvement to No. 935,796 for the manufacture of metallic magnesium. It consists of electrolyzing molten chlorides of magnesium and potassium, using a carbon anode and a cathode of molten tin or copper. The magnesium separated from the electrolyte is alloyed with the molten cathode, which is removed when it contains sufficient magnesium for further treatment. In the second step the magnesium alloy is used as anode, the electrolyte is of the same nature as before, except with the addition of a heavy salt of an electropositive metal such as barium chloride. In the second electrolysis, magnesium enters the solution from the impure anode and deposits on the cathode, so arranged that the magnesium separated may float upon the electrolyte. The tin or copper remaining at the end is much more easily purified of the silicon, iron and calcium ordinarily present than is the formerly-used aluminium, while the magnesium resulting is not harmed by the traces of copper or tin contained. (1,258,261; assigned to American Magnesium Corporation; Mar. 5, 1918.)

Synopsis of Recent Chemical and Metallurgical Literature

"Nicu" Steel and Its Manufacture.—A paper advocating a radical revision in metallurgical practice as applied to the Sudbury nickel ores was read before the Montreal Metallurgical Association at the April, 1918, meeting, by G. M. COLVOCORESSES of Humboldt, Ariz. He noted the fact that Sudbury produced 85 per cent of the world's nickel, of which 75 per cent was added to open-hearth furnaces to produce nickel-steel. At the same time, 650,000 tons of iron valued at 14 million dollars contained in the Sudbury ores are slagged and wasted annually. Present metallurgical practice on nickel ores closely parallels copper smelting up to the production of a white metal containing 80 per cent combined nickel and copper, which converter product is further refined and separated by either the Orford or the Mond process. Available details of the mining and metallurgy of such ores are given fully in the excellent 1917 Report of the Royal Ontario Nickel Commission. Consideration of the average analysis of Sudbury ores given in Table I leads to the conclusion, however, that the ore is one of iron, and should be treated accordingly.

New Caledonia ships a garnierite ore, essentially a hydrous silicate of nickel and magnesium (Table I, which is ordinarily mixed with a sulphide ore for matte smelting. In 1880 some of this ore was locally smelted in a small blast furnace to a "fonte" or impure nickel pig, containing 66 per cent nickel and 24 per cent iron, but the process was not successful owing to a variety of reasons, including the difficulty of preventing considerable sulphur entering the pig from impure coke. More recently, however, this ore has been smelted with iron ores in the electric furnace and the best nickel-steel produced. The process bids fair to become standard for the treatment of this peculiar material.

Recent developments of the multiple hearth roaster have enabled one to dead-roast sulphide ores, using a relatively small amount of extraneous fuel to reduce the sulphur from 3 to 4 per cent to 0.3 to 0.5 per cent. Properly mixed with a flux, the calcine may be delivered in a nodulized condition suitable for blast furnace smelting. The coming of the electric furnace has also enabled the metallurgist to reduce the sulphur in steel made from fairly impure materials to any reasonable amount. Evidently, then, the Sudbury ores could now be roasted and smelted direct, were it not for the universal prejudice existing against any alloy steels containing copper. This is in spite of such results as were obtained in 1909 by Burgess and Aston, who concluded that copper would replace nickel satisfactorily to a certain extent in low carbon alloy steels. Clamer also experimented carefully and took out patents on a method of smelting roasted copper-nickel matte with iron ores into a satisfactory alloy steel. Monel scrap (containing 70 per cent Ni, 27 per cent Cu) has been extensively used in place of pure nickel in the manufacture of alloy steels which have sold under the name of "nickel-steel," withstanding successfully various physical tests, and being manufactured into armor-piercing shells and high grade automobile parts.

Sjostedt and Ulke of the Lake Superior Corporation (operating at the "Soo" in 1901) first worked on the production of ferro-nickel from Canadian ores. "Nicu" steel has been made in laboratory furnaces for several years, and in commercial quantities in a leased plant in East Montreal during the fall of 1917. A low grade ore was used which had been mined for some 20 years, and meantime had weathered, oxidized and disintegrated. This was roasted to 0.4 per cent S in a coal fired reverberatory heating furnace, hand rabbled. It was then charged to a 6-ton Heroult tilting furnace, six or eight charges of the following composition being required to make a heat:

1400 pounds calcine
535 pounds burned lime
375 pounds coke breeze.

Slag was poured at intervals, and the resulting pig, of the analysis given in Table I, refined in an open-hearth furnace of the standard type. No particular extra expense or trouble was encountered in this last operation; 72 tons of steel were made, and subjected to a wide variety of tests demonstrating it to be apparently equal to nickel-steel whose Ni content equalled the Ni + Cu in the "Nicu" steel.

TABLE I—ANALYSES OF VARIOUS NICKEL-COPPER PRODUCTS

Element	Average Sudbury Ore	New Caledonia Garnierite	Weathered Ore Smelted	Pig Iron Produced	Steel Made
Ni	3.25	5	1.3	2.2	2.13
Cu	1.7	..	0.28	0.4	0.4
Fe	40.0	10	46.0	....	....
S	25.0	..	8.0	0.09	0.03
P	....	..	....	0.07	0.006
Si	20.0	33	19.0	1.75	0.03
C	....	..	.....	3.0	0.2

The author presents cost data which lead to the conclusion that under 1916 conditions "Nicu" steel equivalent to a 3 per cent nickel-steel (selling at $60) can be produced in quantity at $30 per ton, scrap being figured at $16 per ton. The process recovers 98 instead of the present 80 per cent of the nickel in the ore, 98 instead of 83 per cent of the copper, and 96 per cent instead of none of the iron. The increased saving if applied to all Sudbury ores would amount to $41,000,000, which is practically equal to the present returns. In commercial operation on a large scale, the nodulized calcine would be mixed with iron-silicate slags and iron ores and smelted to an alloy pig containing 0.2 per cent sulphur. The molten pig would be charged directly to the refining furnace, where a basic slag would remove the bulk of the remaining sulphur and the composition could be carefully adjusted to specification.

Size of Grog in Fire Clay Bodies.—In Technologic Paper No. 104 of the Bureau of Standards F. A. KIRKPATRICK discusses the effect of the size of grog upon the strength and other properties of fire clay bodies. The grog was made by crushing and sizing high-grade fire brick to the following fractions: 4 to 8 mesh, 8 to 12, 12 to 20, 20 to 40. 40 to 80, and 80 to dust. Various combinations of these fractions were then made, proportioned with 50 per cent by weight of plastic fire clay ground through 20 mesh, and molded by hand into briquets 1 x 1 x 7 in. Seven series of mixtures were studied, sufficient work being done to construct tri-axial diagrams showing lines of equal strength, porosity, etc.

Unburned briquets were air dried three days, then one day at 65 deg. C. and two days at 110 deg. Seven briquets of each mixture were broken in a transverse bending machine and the modulus of rupture averaged to give a value for strength. The porosity was determined by immersing in kerosene for 12 hours at 0.2 atmosphere and determining the increase in weight. The tri-axial diagrams representing the modulus of rupture for the various mixtures show isō-strength lines. Some of the series were not coördinate in results for porosity and strength, which phenomenon the author explains thus: The porosity of briquets made of large grog is less than those containing moderately fine particles because the larger particles are more dense than an equal weight of packed smaller ones, and also because the voids were increased by a mixture of grog-sizes. The strength of certain of these mixtures, however, varies directly instead of inversely with the porosity (which latter is the general rule for ceramic materials) because in these cases the larger particles of grog gave weaker bodies due to a lack of bond and contact between clay and grog, causing small cracks in drying. These cracks were the finer with fine aggregates of grog. If the ratio of size and shape of the voids in clay-grog bodies is such that the smaller particles do not fit into the voids but separate the larger bodies, then there will be no areas of maximum strength or density appearing in the corresponding tri-axial diagrams. As above noted, a mixture of sizes giving the maximum density by packing into the voids left by each larger size gives the highest strength.

In mixtures where half the fire clay was replaced by Georgia kaolin the corresponding briquets decreased 60 per cent in strength. When the fire clay was totally replaced by Illinois kaolin, however, corresponding mixtures showed less bonding power with coarse grog but very much more with fine grog than had the pure fire clay. Mr. Kirkpatrick notes that the kaolin was of putty-like consistency, while the fire clay was sticky and contained more colloidal matter. Therefore, kaolin should be expected to make weaker—less dense—mixtures. However, kaolin evidently had certain percentages of grains fitting into the voids between the finest grog, giving with these more dense and stronger bodies. The author concludes that the size of grain of the bond clay has as much effect as that of the grog. Since the size of grain of clay cannot be directly determined in the present state of our knowledge of disperse systems, systematic experimentation such as is done in this publication appears to be the only method of determining the best mixtures for strength and other physical characteristics.

Burned briquets were tested in three series: one burned two hours at 1200, another at 1250 and the third at 1300 deg. C. After burning, the briquets were tested for strength in bending. In these tests the average difference from the mean value was about 10 per cent. Burned briquets were also tested for porosity, volume shrinkage and resistance to sudden temperature changes. In the latter test six pieces of each composition were heated to 600 deg. C. and quenched in ice water five times in succession, the modulus of rupture was determined, and the percentage diminution computed. The number of quenchings to produce failure seems to be no criterion for small pieces, but the author determined that a standard brick should resist from two to three times as many quenchings as the 1 x 1 x 7 in. briquets.

The test results show an erratic relation between porosity (or shrinkage) and strength. The conclusion is that the porosity should not be taken as a criterion of strength in a burned brick, because its effect is often overridden by other factors. However, the relation betwen the "surface factor" of the grog and the strength of the briquet plots as a straight line (except for regions of large grog sizes) for all three heat treatments and is therefore an accurate index of the strength. The rate of gain in strength increases with temperature of burning, since the rate of solution of the finer particles is more rapid. The coarser grog mixtures stood the quenching tests best, and since the results at 600 deg. C. closely agree with those at 1000 deg., the lower and more readily handled temperature is recommended for such work. A grog furnished by a large maker of refractories approximated closely one of the mixtures giving a maximum strength, showing that a good surface factor can be had in practice by careful attention to the crushing system.

Effect of Dielectric Deposits on Cottrell Operation.—E. R. Wolcott in the *Physical Review*, Vol. 12, p. 284, notes that early experience with certain Cottrell plants developed the baffling fact that after operation for a few hours the potential difference between electrodes was lowered to such a degree that the designed power input could not be carried below a safe amperage. This phenomenon occurred in plants treating a non-conducting fume, like sulphur. He therefore investigated the effect of various substances interposed in the gap between a spark and plate, and re-established the previously known facts that the sparking potential is greater if the point is negative for gaps larger than 2.3 mm. (being $2\frac{2}{3}$ times as great at 6 cm.); that the voltage required to start a spark is greater than that necessary to maintain it; and that the voltage required to arc a considerable amperage is higher than that producing a snappy spark consuming a very small amount of power. In addition he found that introducing dielectrics into the gap produced changes in the arcing voltage varying as their nature, continuity, surface condition and position. By careful adjustment a silent glow was produced and photographed, showing it to emanate from the edge of a perforation in a piece of paper resting on the plate. Edges or perforations in thin sheets of mica and glass and a very thin deposit of flowered sulphur or sintering-machine dust was sufficient to lower the arcing voltage approximately one-half.

The roughened, porous or discontinuous surface accumulates a charge sufficient to ionize the surrounding gas, producing the typical glow of the positive discharge and increasing the conductivity of that portion of the gap. No lowering of the sparking voltage results when this charge is conducted away, such as is done by precipitated moisture or by a superimposed grounded screen.

Reinforced Waterproof Paper

Arthur D. Little, Inc., of Cambridge, Mass., have perfected a cotton cloth reinforced waterproof paper which will soon be placed on the market. Heavy grades as strong as burlap such as packing house concerns use for heading barrels of provisions will also find special use in making packages for various chemicals.

Book Reviews

TECHNICAL CHEMISTS' HANDBOOK. By *George Lunge*, Ph. D. Flexible leather, duodecimo (12 x 18 cm.), 264 pages; price $3.50 net. New York: D. Van Nostrand Company.

The second edition of this well-known handbook. It is brief, condensed, and the data well chosen. The analytical methods cover the manufacture of heavy inorganic chemicals only, and not metallurgy, inorganic chemistry, or the finer chemical products. In each case only the best, standard method is given, "in order to avoid discrepancies." It can thus be seen that the spirit of the work is eminently practical, and not one of scientific precision.

HANDBOOK OF OIL ANALYSIS. By *Augustus H. Gill.* Pages 210. Price $2.50. Philadelphia: J. B. Lippincott Co.

The excellent handbook of oil analysis by Dr. Gill has now reached an eighth edition. This bespeaks in striking terms its widespread usefulness in the arts with which it deals. The additions and changes noted in this edition cover a description of the new McMichael viscometer and tests on lubricating oils, some revision of special oils and greases, and methods of the analysis of edible and hardened fats and oils have been brought up to date. For a handy, condensed and competent book on the analysis of oils, this book is to be recommended for a laboratory text book and ready reference.

ORGANIC COMPOUNDS OF ARSENIC AND ANTIMONY. By *Gilbert T. Morgan, D. Sc.*, Professor of Applied Chemistry, City and Guilds Technical College, Finsbury, London, England. Longmans, Green & Company, 1918. 8vo., 376 pp. Price $4.80 net.

The appearance of such an excellent monograph as Professor Morgan's will be welcomed, not only by those to whom the work will be useful, but by all chemists who derive a certain amount of satisfaction in knowing that an important special field of research has been mapped in a thorough manner.

It is a pity that our universities, burdened as they are financially, are practically unable to subsidize or otherwise encourage their professors to write scientific works other than Outlines, Introductory Courses, General Principles etc., such as underpaid and overworked professors are in the habit of writing in order to buy bread and beans for themselves and their families. Professor Morgan's excellent book is therefore most unusual. The thought even suggests itself that the trustees of the City and Guilds College of Finsbury, London, must have had their attention diverted by something, perhaps the war, or they might have seen to it that Professor Morgan did not have "leisure" or "spare time" to write such a book.

It seems to the reviewer that Professor Morgan's book embodies all the features which an excellent scientific monograph should. It contains an excellent bibliography and discusses all of the earlier work which is important, including particularly the work of Bèchamp. The author uses structural formulae freely, which greatly facilitates following the chemical changes involved in what are fairly complex substances. The subject is brought practically up to date, that is up to the end of 1917. The author naturally gives considerable attention to atoxyl and its derivatives and the developments which led to the discovery and application of salvarsan, neosalvarsan, luargol, gallyl etc. While the details of the preparation of many of these compounds are given, it might have been pointed out that the successful preparation of many of them requires a degree of skill and experience such as comparatively few organic chemists attain.

The chemistry of the organic compounds of antimony places this series of compounds with those of arsenic and Professor Morgan has dealt with them in the same thorough manner as the arsenic derivatives, although the latter have proven of much greater value to the physician.

The clinical results of many thousands of cases are given which indicate the latest results of clinical practice with all of the more important derivatives, including the newest. While evidently intended primarily for chemists, the book will undoubtedly prove of value and interest to physicians as well.

Personal

MR. C. E. LEN. ARNOLD, formerly with the Inspiration Consolidated Copper Co., at Inspiration, Ariz., has accepted a position with the Consolidated Arizona Smelting Co. at Mayer, Ariz.

MR. JAMES CHESTER ASHBY, who has been instructor in chemistry at Lehigh University, South Bethlehem, Pa., for some time, is now with the Buffalo Works of the National Aniline & Chemical Co. in the research laboratory.

MR. F. D. BAKER, who has been with the Colorado Department of the American Smelting & Refining Co. for twenty years as chief designing and construction engineer, retired Jan. 1, 1919. Mr. Baker will continue work in a limited consulting practice at Denver, Colo., with his sons.

MR. CHARLES Y. CLAYTON, recently with the Department of the Interior, Bureau of Mines, Pittsburgh, Pa., has become connected with the Missouri School of Mines, Dept. of Metallurgy and Ore Dressing, Rolla, Mo.

PROF. G. H. CLEVENGER is now with the National Research Council, Washington, D. C., having completed the research work at Colorado Springs for the U. S. Bureau of Mines.

MR. W. M. CORSE, who was general manager of the Titanium Bronze Co., Niagara Falls, N. Y., has accepted a position as manufacturing engineer with the Ohio Brass Co., Mansfield, Ohio.

DR. R. W. HESS has recently accepted a position as senior research chemist with the National Aniline & Chemical Co., Buffalo, N. Y. He was formerly chemist in the dyestuff department of the Chicago plant of the Sherwin-Williams Co.

DR. T. POOLE MAYNARD, Atlanta, Ga., has been made Southern representative of the Research Corporation of New York.

MR. LOUIS O. MONROE has assumed duties as manager of sales and chief engineer for the Clarage Fan Co., Kalamazoo, Mich. Previous to entering the service he was in charge of the Chicago office of the same company.

MR. H. C. PARMELEE, editor of CHEMICAL & METALLURGICAL ENGINEERING, has returned from a two-months' visit to England and France, where he was the guest of the British Government.

MR. A. J. PHILIPPS is now research chemist with the Aetna Explosives Co., Emporium, Pa. He was formerly chief chemist of the Western Alkali Refining Co.

MR. FREDERICK A. SCHEFFLER has become associated with the Fuller Engineering Co. and will make his headquarters at the company's New York office, 50 Church St., Mr. Scheffler was formerly indentified with the Babcock & Wilcox Co.

MR. K. B. THOMAS has resigned his position Jan. 1, 1919, as superintendent of the sulphuric acid department for the Calumet & Arizona Mining Co., Douglas, Ariz., to become associated with the Standard Chemical & Oil Co. of Troy, Ala., as its superintendent.

MR. HORACE N. TRUMBULL, who has recently received his discharge from the Engineers Officers' Training School at Camp A. A. Humphreys, Va., has been appointed advertising manager of the Wellman-Seaver-Morgan Co., of Cleveland, Ohio. Before entering the service, Mr. Trumbull was advertising manager of the S.K.F. Ball Bearing Co., Hartford, Conn.

MR. F. L. WOODS has been appointed superintendent of the Tygert-Allen Works at Philadelphia, Pa., of the American Agricultural Chemical Co., of Weymouth, Mass. He was formerly assistant superintendent of the Bradley fertilizer works of the same company at Weymouth.

Obituary

MR. THOMAS G. BROWN, of Denver, Colorado, died at Lluvia de Oro, in Chihuahua, Mexico, on November 19 of pneumonia following influenza. He was 31 years of age and was graduated from the Golden School of Mines in 1907. After graduation he spent some time in Colorado, being employed at the Tomboy and other mines. In 1910 he joined the staff of the Mines Company of America and was employed at both the Dolores mine, in Chihuahua, and the Creston-Colorada, in Sonora, for a number of years. In April, 1917, he became assayer and chemist for the Lluvia de Oro Gold Mining Co., and in that capacity he was serving at the time of his death.

Current Market Reports

The Non-Ferrous Metal Market

Saturday, Jan. 11.—There has been no buying on any large scale up to date this year. In several cases there have been declines in prices, which are certain to rapidly reach a peace basis. Manufacturers will not order their metal supplies before orders for their product are booked.

Aluminium:—The Government prices on ingots 98 to 99 per cent Al are $660 a ton f.o.b. plant in 50-ton lots; $662 down to 15-ton lots; and $666 down to 1-ton lots, which prices will continue the remainder of the year. Prices per pound for small lots vary from 40c. to 45c.; sheet aluminium, 18 ga. and heavier, 42c.; powdered aluminium, 100 mesh, 70c.

Antimony:—Large stocks of antimony are being held at prices ranging from 7¾ to 8c. per lb.

Copper:—Prime lake is nominal at 23c. Electrolytic is selling at 20¾c. and casting at 19c. The producers are determined to hold their prices high believing that the foreign demand will soon be strong.

Copper sheets, hot rolled	lb.	$0.33 —$0.35
Copper sheets, cold rolled	lb.	.34 — .36
Copper bottoms	lb.	.41 — .43
Copper rods	lb.	.33 — .35
Copper wire	lb.	.23
High brass wire	lb.	.24¼— .26¾
High brass sheets	lb.	.24¼— .26¾
High brass rods	lb.	.23¾— .25¾
Low brass wire	lb.	.26¾— .28¾
Low brass sheets	lb.	.26¾— .28¾
Low brass rods	lb.	.27¼— .29¾
Brazed brass tubing	lb.	.35¾— .37¾
Brazed bronze tubing	lb.	.40¼— .42¼
Seamless copper tubiog	lb.	.35 — .37
Seamless bronze tubing	lb.	.37 — .39
Seamless brass tubing	lb.	.34 — .36
Bronze (gold) powder	lb.	1.00 — 1.75

Tungsten:—Tungsten took a decided decline with best grade scheelite $18.00 and wolframite $16.00.

Zinc:—Spelter continues to decline, spot New York bring $156 to 157 per ton; East St. Louis, $148 to 150, February, $147 and March, $146. Sheet and plate zinc is quoted at 13c. per lb. and prime metallic powder, 14c. lb.

OTHER METALS

Bismuth	lb.	$3.50 — $3.65
Cadmium	lb.	1.50 — .....
Cobalt	lb.	2.50 — 3.50
Magnesium	lb.	1.75 — 2.10
Mercury	75 lb.	110.00 — .....
Mercury	lb.	1.95 — .....
Nickel	lb.	.40 — .45
Tungsten	lb.	34.00 — .....
Iridium	oz.	175.00 — .....
Palladium	oz.	135.00 — .....
Platinum	oz.	105.00 — 108.00
Silver	oz.	1 01⅛— .....

Lead:—Buyers are not taking much interest in lead at present. East St. Louis prices are from $112 to $114 per ton; New York, 5¾ to 6c. lb.; sheet lead is 9c. lb.

Tin:—The tin market is divided into two sections: Government 72½c. tin and outside lots at 70½ with an expected decline to 68c. per lb.

The Iron and Steel Market

Demand for iron and steel since the signing of the armistice has pursued a somewhat different course than was generally expected. Instead of the sudden cessation of hostilities producing a sudden slump in demand with a sharp curtailment in production, to be followed by an early pick-up in demand, the reverse has been the case. For several weeks after the signing of the armistice there was no plethora of steel although production was very well maintained, while now, in the middle of January, steel mill operations are decreasing and there is only a very meager demand.

Production of steel ingots in December was at the rate of 43,750,000 tons a year, showing actually an increase over the November rate, which was 43,000,000 tons a year, not counting time out for celebration of the armistice, while the maximum rate ever attained was 46,800,000 tons, last September. The December rate represented about 90 per cent of capacity, which may be taken at 49,000,000 tons a year. Mills are operating at various rates, but the average seems to be only about 65 per cent, and in view of the lightness of demand a 50 per cent rate is far from impossible in the near future. A 50 per cent rate on present capacity would represent approximately as large an output as was made in any calendar year prior to 1912, so that it really would represent a great deal of steel after all.

PRICES

There is no question about pig iron and steel prices, in face of the light demand. They are strictly maintained, in accordance with the reductions that were made in accordance with the schedule prepared by the Institute committee for presentation to the War Industries Board at the meeting of December 11. The board did not receive the schedule, but the iron and steel industry was keen and efficient to accept and adopt the suggestion. Broadly speaking, the reductions were $3 on pig iron, $4 on unfinished steel and $4 to $7 per net ton on finished products.

It is the lightness of demand that dispels any question about the maintenance of these slightly reduced prices, which are, of course, about double the ten-year pre-war average. There is no incentive on the part of producers to cut prices, slightly or heavily, for there will be more buying for a time at established prices than there would be in a disorganized market, and further cuts could hardly be made without precipitating demoralization. The time will come when it will be advantageous for the producers to bargain with buyers, when the buyers appear in such force as to show that price really counts. At the present time buying is of purely hand to mouth character.

The present demand, such as it is, does not represent new buying in any considerable measure, but rather, in the case of pig iron, the acceptance of shipments against old contracts, and in steel products the placing of specifications or shipping orders against old contracts. In steel products the contracts are, as is well understood, but little more than options given the buyer, who specifies or not as he desires. For this reason steel is being furnished under old contracts at the reduced prices, the mills readily making the necessary adjustments with customers. Even the sheet manufacturers, who adopted the "binding form" of contract a couple of years ago, have made these adjustments. The blast furnaces, which make firm contracts, not option-contracts such as obtain in the steel trade, are as a rule making the $3 concession to customers.

CHARACTER AND DEMAND

By far the heaviest steel demand at present is from the automobile trade, which will probably use more steel than ever during the next few months. The Emergency Fleet Corporation is taking a considerable tonnage, but its re-

quirements are scaled down from the rate that obtained in the closing months of the war, as there is a large accumulation of steel, more than a million tons, to be worked off. Jobbers are buying and specifying moderate tonnages, requiring very prompt deliveries in all cases and being quite unwilling to commit themselves as to the future. Much the same policy obtains with ordinary manufacturing consumers. There is practically no demand for steel for regular construction jobs, buildings, bridges, factories, power stations and the like, nor is there any evidence that such demand will develop in the near future.

There is some cleaning up of orders for railroad steel, very little in rails, but a fair tonnage in car and locomotive material. There is no new business in sight in railroad steel, and a comprehensive program of railroad buying cannot of course be formulated until it is determined what is to be done with the railroads. Congress will take its own time in that matter.

Throughout the iron and steel trade the prediction is still made freely and with confidence that there is in store a period of several years of great activity. It is likewise admitted that the period will not begin for a while yet, a period of readjustment intervening. Apparently this readjustment is expected to proceed under its own steam and its own guidance. It does not seem to be regarded as anybody's business to help the readjustment along or even to study the subject. One branch of this readjustment, however, must properly be left to circumstances. There must be awaited a dying out of the wave of bolshevism in Europe, and certain psychological reactions in the minds of workingmen in the United States, whereby they will become disposed to regard a job as an asset and become willing to render a day's service for a day's wage.

Chemical Market

COAL-TAR PRODUCTS:—Although there is a continued dullness in the coal-tar product market, it would seem that more than the ordinary seasonable quietness is prevailing, to such an extent that many of the items that come under this heading are almost at a standstill. At the present it is too early in the year to have had any material effect, although there is a strong undertone evident and inquiries in the trade for export purposes have been quite active, but the shipping situation is generally considered the handicap for extensive trading in this direction. It is believed, however, that as soon as this condition develops to be easier a splendid business will set in. Toluol is now in easy supply, with phenol being freely offered in the market at some unheard of prices, but producers appear to be in a position to keep benzol in a firm condition, although stocks on hand are plentiful.

Toluol:—Resale offerings of this product are made at 5c. below the manufacturer's price, while quotations from first hands are firm at the recent decline.

Phenol:—The material has developed to be the most unsettled product of the crudes. Producers are making price concessions with no favorable results and the offerings through second hands, which are 10c to 15c below the manufacturer's prices, seem to originate no buying interest.

Benzol:—This product is subject to no pressing call; however, it is held in strong hands and prices are firmly maintained.

Phthalic Acid:—The item is being produced in more liberal quantities and therefore the additional demand that has been in evidence during the recent period has not affected the situation to any noticeable extent. Manufacturers' prices are quotably unchanged for the crude or the anhydride.

Acid Sulphanilic:—Dealers are looking forward to some activity for this material, which has been considerably neglected, and no price revisions have taken place in view of this feeling.

Aniline Oil:—Up to the present writing there has been no price change reported for this product, which continues in light demand.

Aniline Salt:—Price concessions are being made by manufacturers and dealers, but consumers are seemingly purchasing only for immediate needs. Stocks in the various directions are in sufficient quantities to take care of additional business.

Benzaldehyde:—The routine demand that is in evidence for this product is well taken care of, as supplies in the market are now considerably easier and there has been a general decline in prices.

Benzidine:—Buyers are still holding off and the only business of importance that is passing is for the base material, while the sulphate seems to be considerably neglected and manufacturers have made some substantial downward revisions in prices.

HEAVY CHEMICALS:—Actual business in heavy chemicals during the interval has been of moderate proportions. However, the holiday season passed and the inventory period nearing completion seems to be a source of satisfaction throughout the trade, although there are no indications of any immediate activities and it is generally believed this will not take place until conditions are more favorable for export purposes. In the meantime most of the items that come under this heading have been subject to a decline in prices, with only the medicinal products holding firm. Caustic soda and soda ash, the barometers of the heavy chemicals, have again come in for a trying period and weak holders play havoc with the market.

Caustic Soda:—The tone of this market has been decidedly easier during the latter period of the past week with buyers' views considerably below the market prices, which have declined from 10c. to 20c. per hundred pounds. The 76 per cent solid product from the warehouse was available at $3.30 per hundred pounds, while ex-dock quotations range from $3.20 to $3.30, according to seller. Dealers during the latter part of the week were not disposed to offer f.a.s. owing to the unsettled conditions with labor at the docks. Ground caustic appears to be subject to no important call and was offered at from $4.25 to $4.50 per hundred pounds.

Soda Ash:—There is no indication of any immediate activity for any of the various packings and during the week light ash in hardwood barrels appears to have been the only one of the items subject to any call and this was for no pronounced quantity. Bags from the warehouse were quoted at from $1.90 to $2.00 per hundred pounds, while material rolling was offered at $1.80 New York. Double bags at Middle Western shipping points were held at from $2.40 to $2.50, while material in regular barrels was quoted at $2.30 to $2.45 ex-warehouse and hardwood barrels were offered at $3.35 f.a.s. Dense ash in barrels was held at $3.50 f.a.s., and on the Pacific Coast offerings were heard at $3.60 ex-warehouse.

Bleaching Powder:—Resale material has been rather difficult to dispose of; however, export drums appear to be the only item that has been subject to any noticeable call, while domestic drums are being more freely offered. At Niagara large domestic drums were quoted at $1.90, while first hands were holding at 2c per pound and 3¼c seems to be the general asking price for export drums, while in the resale market offerings were made at 3c to 3⅛c.

Bichromate of Potash:—Most dealers continue to quote 37c to 38c per pound for this material, for which manufacturers report a satisfactory call, but the consuming demand is not pressing and stocks are in sufficient quantities to take care of additional business.

Bichromate of Soda:—A fair inquiry prevails for this material both for export and domestic consumption. First hands report stocks in reasonable quantities and are quoting 18c to 18½c, while in the resale market frequent lots appear and sales are passing at from 17c to 17½c per pound.

Cyanide of Soda:—Most dealers continue to quote the 96 to 98 per cent product at from 30c to 31c per pound, while the chloride mixture of 73 to 76 per cent is held at 25c to 27c per pound and the chloride carbonate mixture is offered at from 20c to 21c. Movement is of no important character and only the routine business is in evidence.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET JAN. 10, 1919

Acetic anhydride	lb.	1.00	—	1.25
Acetone	lb.	.25½	—	.25½
Acid, acetic, 28 per cent	cwt.	5.00	—	5.50
Acetic, 56 per cent	cwt.	8.50	—	9.50
Acetic, glacial, 99½ per cent, carboys	cwt.	19.00	—	19.20
Boric, crystals	lb.	.13¾	—	.15
Citric, crystals	lb.	1.24	—	1.25
Hydrochloric, C. P	lb.	Nominal		
Hydrofluoric, 30 per cent, in barrels	lb.	.08	—	.08½
Lactic, 44 per cent	lb.	.14	—	.15
Lactic, 22 per cent	lb.	.06	—	.07
Molybdic, C. P	lb.	6.90	—	7.40
Nitric, 36 deg	lb.	Nominal		
Nitric, 42 deg	lb.	.08½	—	.10
Oxalic, crystals	lb.	.36	—	.38
Phosphoric, 47-50 per cent paste	lb.	.07½	—	.10
Phosphoric, ref. 50 per cent	lb.	.35	—	.40
Picric	lb.	.75	—	.85
Pyrogallic, resublimed	ton	3.25	—	3.50
Sulphuric, 60 deg	ton	16.00	—	...
Sulphuric, 66 deg	ton	25.00	—	...
Sulphuric, oleum (Fuming), tank cars	ton	60.00	—	65.00
Tannic, U. S. P., bulk	lb.	1.40	—	1.50
Tartaric, crystals	lb.	.86	—	.95
Tungstic, per lb. of W	lb.	1.70	—	1.75
Alcohol, sugar cane, 188 proof	gal.	4.91	—	...
Alcohol, wood, 95 per cent	gal.	.91½	—	.92
Alcohol, denatured, 180 proof	gal.	.68	—	.69
Alum, ammonia lump	lb.	.07½	—	.08½
Alum, chrome ammonium	lb.	.18	—	.19
Alum, chrome potassium	lb.	.20	—	.22
Alum, chrome sodium	lb.	.12½	—	.13
Alum, potash lump	lb.	.09½	—	.10
Aluminium sulphate, technical	lb.	.02½	—	.02½
Aluminium sulphate, iron free	lb.	.04¼	—	.04½
Ammonia aqua, 26 deg., carboys	lb.	.08¾	—	.09
Ammonia, anhydrous	lb.	Nominal		
Ammonium carbonate	lb.	.12	—	.13
Ammonium nitrate	lb.	(Fixed Price)		.15
Ammonium, sulphate domestic	gal.	.07½	—	.08
Amyl acetate	lb.	5.30	—	5.35
Arsenic, white	lb.	.11	—	.13
Arsenic, red	ton	.65	—	.70
Barium carbonate, 99 per cent	ton	80.00	—	90.00
Barium carbonate, 97-98 per cent	ton	65.00	—	67.00
Barium chloride	lb.	65.00	—	75.00
Barium sulphate (Blanc Fixe, Dry)	lb.	.04½	—	.05
Barium nitrate	lb.	.11½	—	.12
Barium peroxide, basis 70 per cent	lb.	.30	—	.32
Bleaching powder, 35 per cent chlorine	lb.	.02	—	.03½
Borax, crystals, sacks	ton	.08¼	—	.08¼
Brimstone, crude	lb.	65.00	—	70.00
Bromine, technical	lb.	.75	—	...
Calcium, acetate, crude	lb.	.04	—	.05
Calcium, carbide	ton	.12	—	.14
Calcium chloride, 70-75 per cent, fused, lump	lb.	22.00	—	24.00
Calcium peroxide	lb.	1.50	—	1.70
Calcium phosphate	lb.	.22	—	.23
Calcium sulphate, 98-99 per cent	lb.	.09	—	.09½
Carbon bisulphide	lb.	.08	—	.09
Carbon tetrachloride, druma	lb.	.15	—	.16
Carbonyl chloride (phosgene)	lb.	1.10	—	1.50
Caustic potash, 88-92 per cent	100 lb.	.62	—	.65
Caustic soda, 76 per cent	lb.	3.30	—	3.50
Chlorine, liquid	lb.	.10	—	.12
Cobalt oxide	lb.	1.60	—	1.65
Copperas	lb.	.01½	—	.02½
Copper carbonate	lb.	.30	—	.31
Copper cyanide	lb.	.75	—	.78
Copper sulphate, 99 per cent, large crystals	lb.	.09	—	.09½
Cream of tartar, crystals	100 lb.	.63	—	.68
Epsom salt, bags, U.S P	lb.	2.75	—	...
Formaldehyde, 40 per cent	lb.	.21½	—	.22
Glauber's salt	lb.	.02	—	.02½
Glycerine, bulk, C.P	lb.	.20	—	.21
Iodine, resublimed	lb.	4.25	—	4.30
Iron oxide	lb.	.06	—	.08
Lead acetate, white crystals	lb.	.17	—	.17½
Lead arsenate (Paste)	lb.	.15	—	.18
Lead nitrate, C. P.	lb.	.85	—	.86
Litharge, American	lb.	.12	—	.14
Lithium, carbonate	lb.	1.50	—	2.05
Magnesium carbonate, technical	lb.	.16	—	.17
Nickel salt, single	lb.	.14	—	.15
Nickel salt, double	lb.	.12	—	.13
Phosgene (see Carbonyl chloride)	lb.	1.10	—	1.50
Phosphorus, red	lb.	1.00	—	1.15
Phosphorus, yellow	lb.	.85	—	1.10
Potassium bichromate	lb.	.38	—	.40
Potassium bromide granular	lb.	1.25	—	1.26
Potassium carbonate calcined, 85-90 per cent	lb.	.38	—	.40
Potassium chlorate, crystals	lb.	.38	—	.40
Potassium cyanide, 98-99 per cent	lb.	.60	—	.70
Potassium iodide	ton	3.75	—	3.80
Potassium muriate, 80-85 p. c. basis of 80 p. c	lb.	300.00	—	350.00
Potassium nitrate	lb.	.27	—	.31
Potassium permanganate, U. S. P	lb.	1.30	—	1.50
Potassium prussiate, red	lb	2.30	—	2.50
Potassium prussiate, yellow	ton	.80	—	.90
Potassium sulphate, 90-95 p. c. basis 90 p. c	lb.	Nominal		
Rochelle salts	lb.	46½	—	.48
Salammoniac, gray gran	lb.	.19	—	.20
Salammoniac, white gran	100 lb.	.16	—	.17
Sal soda	ton	1.40	—	1.65
Salt cake		18.00	—	20.00
Silver cyanide, based on market price of silver	oz.	...	—	...
Silver nitrate	oz.	.63½	—	.64
Soda ash, 58 per cent, light, flat (baga)	100 lb.	1.95	—	2.00
Soda ash, 58 per cent, dense, flat	100 lb.	3.35	—	3.50
Sodium acetate	lb.	.18½	—	.20
Sodium bicarbonate, domestic	lb.	.02¾	—	.03
Sodium bicarbonate, English	lb.	...	—	...
Sodium bichromate	lb.	.17½	—	.18½
Sodium bisulphite, powd	lb.	.12	—	.14
Sodium chlorate	lb.	.18	—	.20
Sodium cyanide	lb.	.30	—	.35
Sodium fluoride, commercial	lb.	.16	—	.17
Sodium hyposulphite	lb.	3.10	—	3.50
Sodium molybdate, per lb. of Mo	lb.	2.50	—	...
Sodium nitrate, 95 per cent	100 lb.	4.42	—	4.55
Sodium nitrite	lb.	.19	—	.20
Sodium peroxide	lb.	.35	—	.45
Sodium phosphate	lb.	.04	—	.04½
Sodium prussiate, yellow	lb.	.34	—	.36
Sodium silicate, liquid (60 deg.)	lb.	.03	—	.04
Sodium sulphide, 30 per cent, crystals	lb.	.02	—	.03
Sodium sulphide, 60 per cent, fused	100 lb.	.05	—	.06
Sodium sulphite	lb.	.05½	—	.06
Strontium nitrate	lb.	.25	—	.30
Sulphur chloride, druma	lb.	.07½	—	.09
Sulphur dioxide, liquid, in cylinders	lb.	.15	—	.40
Sulphur, flowers, sublimed	100 lb.	4.35	—	4.50
Sulphur, roll	100 lb.	3.70	—	3.85
Sulphur, crude	ton	65.00	—	70.00
Tin bichloride, 50 deg	lb.	.28	—	.29
Tin oxide	lb.	.90	—	1.00
Zinc carbonate	lb.	.18	—	.20
Zinc chloride	lb.	.15	—	.15½
Zinc cyanide	lb.	Nominal		
Zinc dust, 350 mesh	lb.	.13½	—	.14
Zinc oxide, American procesa XX	lb.	.10½	—	.12
Zinc sulphate	lb.	.04¼	—	.06¼

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	22	—	27
Benzol, 90 per cent	gal.	25	—	...
Toluol, in tank cars	gal.	25	—	...
Toluol, in druma	gal.	30	—	35
Xylol, pure, water white	gal.	45	—	55
Solvent naphtha, water white	gal.	18	—	25
Solvent naphtha, crude, heavy	gal.	12	—	15
Creosote oil, 25 per cent	gal.	45	—	55
Dip oil, 20 per cent	gal.	35	—	40
Pitch, various grades	ton	8.00	—	20.00
Carbolic acid, crude, 95-97 per cent	lb.	Nominal		
Carbolic acid, crude, 50 per cent	lb.	Nominal		
Carbolic acid, crude, 25 per cent	lb.	Nominal		
Cresol, U. S. P	lb.	18	—	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00	—	1.10
Alpha naphthol, refined	lb.	1.50	—	1.60
Alpha naphthylamine	lb.	.55	—	.60
Aniline oil, drums extra	lb.	.27	—	.30
Aniline salts	lb.	.40	—	.42
Anthracene, 80 per cent	lb.	6.00	—	...
Benzaldehyde (f.f.c.)	lb.	4.25	—	4.50
Benzidine, base	lb.	1.45	—	1.60
Benzidine, sulphate	lb.	1.15	—	1.25
Benzoic acid, U. S. P	lb.	1.90	—	2.15
Benzoate of Soda, U. S. P	lb.	1.75	—	1.90
Benzyl chloride	lb.	2.45	—	2.50
Beta naphthol benzoate	lb.	10.00	—	12.00
Beta naphthol, sublimed	lb.	.75	—	.85
Beta naphthylamine, sublimed	lb.	2.65	—	...
Dichlor benzol	lb.	.15	—	.20
Diethylaniline	lb.	3.25	—	4.00
Dinitro benzol	lb.	.36	—	.38
Dinitrochlorbenzol	lb.	.39	—	.41
Dinitronaphthaline	lb.	.55	—	.60
Dinitrotoluol	lb.	.40	—	.50
Dinitrophenol	lb.	.49	—	.50
Dimethylaniline	lb.	.70	—	.73
Diphenylamine	lb.	1.00	—	1.10
H-acid	lb.	2.85	—	3.10
Metaphenylenediamine	lb.	1.85	—	2.05
Monochlorbenzol	lb.	.16	—	.19
Naphthalene, flake	lb.	.09	—	...
Naphthalene, balls	lb.	.12	—	.12½
Naphthionic acid, crude	lb.	1.20	—	1.30
Naphthylamin-di-sulphonic acid	lb.	1.00	—	1.10
Nitro naphthaline	lb.	.45	—	.50
Nitro toluol	lb.	.55	—	.60
Ortho-amidophenol	lb.	6.00	—	7.00
Ortho-dichlor-benzol	lb.	.15	—	.20
Ortho-toluidine	lb.	1.00	—	1.10
Ortho-nitro-toluol	lb.	.75	—	.85
Para-amidophenol, base	lb.	4.25	—	...
Para-amidophenol, H. C. L	lb.	4.25	—	5.00
Para-dichlor-benzol	lb.	.15	—	.20
Paranitraniline	lb.	1.50	—	1.70
Para-nitro-toluol	lb.	1.50	—	1.60
Paraphenylenediamine	lb.	3.25	—	3.50
Para toluidine	lb.	2.25	—	2.50
Phthalic acid anhydride	lb.	3.25	—	3.50
Phenol, U. S. P.	lb.	.20	—	.30
Resorcin, technical	lb.	4.50	—	5.00
Resorcin, pure	lb.	7.00	—	8.00
Salicylic acid U. S. P	lb.	.77	—	.85
Salol	lb.	1.50	—	2.00
Sulphanilic acid, crude	lb.	.31	—	.33
Toluidine	lb.	2.50	—	3.00
Toluidine-mixture	lb.	1.00	—	...

Petroleum Oils

Crude (at the Wells)

Pensylvania	bbl.	4.00	—	...
Corning, Ohio	bbl.	2.85	—	...
Somerset, Ky	bbl.	2.60	—	...
Wooster, Ohio	bbl.	2.68	—	...
Indiana	bbl.	2.28	—	...
Illinois	bbl.	2.42	—	...
Oklahoma and Kansas	bbl.	2.25	—	...
Caddo, La., light	bbl.	2.25	—	...
Corsicana, Tex., light	bbl.	2.25	—	...
California	bbl.	1.24	—	1.57
Gulf Coast	bbl.	1.35	—	...
Mexican	bbl.	1.90	—	...
Fuel Oil				
New York	gal.	15	—	...
Philadelphia	gal.	10¼	—	...
Baltimore	gal.	.07½	—	.15
Pittsburgh	gal.	.07½	—	10½
Texas	bbl.	1.85	—	2.35
Los Angeles	bbl.	1.65	—	...

Gasoline (Wholesale)

New York, motor	gal.	.24½	—	....
Gas machine	gal.	.41½	—	....
72-76 degrees	gal.	.33½	—	.39½
70-72 degrees	gal.	.32	—	.37½
67-70 degrees	gal.	.30½	—	.36½
Pittsburgh, motor	gal.	.25½	—	....
Chicago, motor	gal.	.22½	—	.23
Oklahoma, motor	gal.	.21½	—	....
San Francisco, motor	gal.	.20½	—	....

Paraffine Waxes

Crude, 103 to 105 deg. m.pt.	lb.	.08½	—	.09
Crude, 118 to 120 deg. m.pt.	lb.	.09½	—	.10
Crude, 124 to 126 deg. m.pt.	lb.	.10	—	....
Refined, 120 deg. m.pt.	lb.	.13½	—	....
Refined, 128 deg. m.pt.	lb.	.14	—	....
Refined, 135 deg. m.pt.	lb.	.16	—	.16½
Ozokerite, brown	lb.	.75	—	.80
Ozokerite, green	lb.	.85	—	.90

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.24	—	.25
Cylinder, light	gal.	.45	—	.50
Cylinder, dark	gal.	.39	—	.43
Paraffine, high viscosity	gal.	.40	—	.41
Paraffine, 0.903 sp. gr.	gal.	.36	—	.38
Paraffine, 0.885 sp. gr.	gal.	.26	—	.28

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f. o. b. Florida	gal.	.44	—	....
Pine oil, steam-distilled, sp. gr. 0.925-0.940	gal.	.58	—	.60
Pine oil, destructively distilled	gal.	.58	—	.60
Pine-tar oil, sp. gr. 1.02-1.035	gal.	.35	—	....
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.42	—	....
Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f.o.b. works	gal.	.37	—	....
Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.28	—	....
Pine-tar oil, ref., thin, sp. gr. 1.060-1.080	gal.	.32	—	....
Turpentine, crude, sp. gr. 0.870-0.900	gal.	.45	—	....
Hardwood oil, f.o.b. Michigan, sp.gr. 0.960-0.990	gal.	.23	—	....
Hardwood oil, f.o.b. Michigan, sp.gr. 1.06-1.08	gal.	.23	—	....
Wood creosote, ref., f.o.b. Florida	gal.	.31	—	....

Naval Stores

Rosin A-E barrel	280 lb.	14.37	—	14.50
Rosin F-I	280 lb.	14.50	—	15.25
Rosin K-N	280 lb.	17.00	—	17.60
Rosin WG-W	280 lb.	17.60	—	18.00
Spirits of turpentine	gal.	.66	—	.77
Wood turpentine, steam distilled	gal.	.64	—	.65
Wood turpentine, destructively distilled	gal.	.58	—	.60
Pitch	bbl. 200 lb.	8.00	—	....
Tar, kiln dried	280 lb.	13.00	—	13.50
Retort tar	280 lb.	14.00	—	14.50
Rosin oil, first run	gal.	.77	—	....
Second run	gal.	.80	—	....
Third run	gal.	.85	—	....
Fourth run	gal.	.95	—	....

Vegetable Oils

Castor oil	lb.	.26	—	.28
China wood oil	lb.	.22	—	.24
Cocoanut oil	lb.	.16	—	.21
Corn oil	lb.	.18	—	....
Cottonseed oil, crude	lb.	.17½	—	.22
Linseed oil, raw, cars	gal.	1.81	—	1.86
Palm	lb.	.18	—	.23
Peanut oil, crude	lb.	.17½	—	....
Soya bean oil, Manchuria	lb.	.16½	—	....

Glues

Extra white	lb.	.31	—	.35
Cabinet	lb.	.25	—	.26
Brown foot stock	lb.	.15	—	.19
Fish glue, 50-gal. barrels	gal.	1.00	—	1.50

Miscellaneous Materials

Barytes, floated, white, foreign	ton	Nominal		
Barytes, floated, white, domestic	ton	33.00	—	36.00
Beeswax, white, pure	lb.	.63	—	.65
Beeswax, unbleached	lb.	.43	—	.48
Blanc fixe	lb.	.05½	—	....
Casein	lb.	.17½	—	.30
Ceylon graphite	lb.	.07½	—	.25
Chalk, light, precipitated, English	lb.	.04½	—	.06
China clay, imported, lump	ton	20.00	—	40.00
China clay, domestic, lump	ton	15.00	—	22.50
Feldspar	ton	8.00	—	12.00
Fluorspar, gravel, f.o.b. mines	ton	28.00	—	40.00
Fluorspar, washed, powdered	ton	90.00	—	....
Fuller's earth, powdered	100 lb.	1.50	—	2.00
Japan wax	lb.	.26	—	.27
Mexican graphite	ton	60.00	—	75.00
Madagascar graphite	lb.	.10	—	.15
Orange shellac	lb.	.72	—	.80
Pumice stone	lb.	.04	—	.08
Red lead, dry, carloads	100 lb.	11½	—	11½
Soapstone	ton	15.00	—	25.00
Stearic acid, 120 deg. m.pt.	lb.	.13	—	.14
Stearic acid, 140 deg. m.pt.	lb.	.18	—	.19
Talc, American, white	ton	20.00	—	40.00
White lead, dry	lb.	.14	—	.14½

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	175.00	—	....
Chrome cement	net ton	75.00	—	....
Clay brick, first quality fireclay	per 1000	50.00	—	55.00
Clay brick, second quality	per 1000	35.00	—	40.00
Magnesite, raw	ton	30.00	—	35.00
Magnesite, calcined, powdered	ton	50.00	—	65.00
Magnesite, dead burned	net ton	50.00	—	60.00
Magnesia brick, 9x4½x2½	net ton	110.00	—	125.00
Silica brick	per 1000	50.00	—	60.00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent, carloads, f.o.b. Niagara Falls, N. Y.	ton	200.00	—	250.00
Ferrocerium	lb.	15.00	—	30.00
Ferrochromium, per lb. of Cr	lb.	.30	—	.40
Ferromanganese, domestic, 70 per cent basis	ton	220.00	—	....
Ferromanganese, English	ton	325.00	—	....
Spiegeleisen (16-18%)	ton	67.50	—	....
Ferromolybdenum, per lb. of Mo	lb.	3.50	—	4.50
Ferrosilicon, 75 per cent, f.o.b. N. Y.	ton	....	—	....
Ferrosilicon, 50 per cent, contract	ton	143.00	—	....
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	Nominal		
Ferrouranium, f.o.b. works, per lb. of U	lb.	7.50	—	....
Ferrovanadium, f.o.b. works	lb.	....	—	....

Ores and Semi-finished Products

Chrome ore, 45 per cent minimum, f.o.b. Cal. per unit	ton	1.50	—	1.55
Chrome ore, 43 per cent and over, New York, per unit	ton	1.40	—	....
Coke	ton	6.00	—	7.00
Manganese ore, 48 per cent and over, per unit	ton	1.20	—	....
Manganese ore, chemical	ton	80.00	—	100.00
Molybdenite, per lb. of MoS_2	lb.	1.25	—	1.50
Tungsten, Scheelite, per unit of WO_3	ton	25.50	—	....
Tungsten, Wolframite, per unit of WO_3	ton	23.00	—	....
Uranium oxide, 96%	lb.	3.25	—	3.60
Vanadium pentoxide, 99%	lb.	10.50	—	....
Pyrites, foreign	unit	.17	—	....
Pyrites, domestic	unit	.28	—	.30½

Plant Supplies

BUILDING MATERIALS

Common clay bricks	M	13.00	—	14.00
Hollow tile, 4x12x12	M	60.00	—	....
Hollow tile, 12x12x12	M	170.00	—	....
Lime	ton	16.50	—	....
Portland cement	bbl.	2.59	—	....
Single glass (82-lb.), 10x26-16x24		21.00	—	27.00
Double glass (164 lb.), 10x26-16x29		31.00	—	39.00
Yellow pine lumber	M	39.00	—	45.00
Fir lumber	M	38.00	—	53.00
Hemlock	M	24.50	—	40.00
Tarred felt (14-lb. sq.)	ton	68.00	—	....
Roofing pitch	ton	27.00	—	....
Asphalt coated roofing (35-55-lb.sq.)	sq.	1.60	—	2.45
Slate surfaced asphalt shingles	sq.	5.25	—	5.50
Corrugated galvanized iron	ton	109.00	—	127.00
Putty	100 lb.	6.25	—	....
Red oxide (Ppte. Copperas)	100 lb.	15.00	—	20.00
Native red oxide	100 lb.	3.25	—	8.00
Red metallic paint	100 lb.	1.20	—	1.50
White lead in oil	100 lb.	15.00	—	16.00
Red lead in oil	100 lb.	12.28	—	14.50
Zinc oxide (dry)	100 lb.	13.00	—	14.50
Zinc oxide—leaded	100 lb.	9.00	—	10.00
Yellow ochre	100 lb.	1.50	—	10.00
Ultra marine blue	100 lb.	14.00	—	50.00
Prussian blue	100 lb.	135.00	—	150.00
Chrome green	100 lb.	40.00	—	70.00
Paris green	100 lb.	43.00	—	49.00
Mineral black	100 lb.	1.75	—	2.25
Powdered bone black	100 lb.	5.50	—	12.00
Lampblack	100 lb.	15.00	—	45.00
Gas carbon	100 lb.	16.00	—	25.00
Mexican petroleum pitch	100 lb.	1.00	—	2.00
Gilsonite	100 lb.	2.00	—	2.50
Coal tar pitch	100 lb.	.60	—	1.25

STRUCTURAL IRON

Blue annealed sheet iron	ton	78.00	—	85.00
Black sheet iron	ton	94.00	—	100.00
Galvanized iron	ton	121.00	—	125.00
Tern plate, 8-lb. coating	ton	150.00	—	....
Tern plate, 15-lb. coating	ton	177.50	—	....
Tern plate, 25-lb. coating	ton	200.00	—	....
Tern plate, 40-lb. coating	ton	240.00	—	....
Tin plate, prime	ton	155.00	—	....
Tank plates	ton	60.00	—	....
Beams, channels, angles, T's, Z's	ton	56.00	—	....
Rivets	ton	88.00	—	92.00
Steel pipe, ¾ to 3-inch	ton	51.00	—	....
Bar iron and steel	ton	60.00	—	70.00
Chain (1 inch proof coil)	ton	150.00	—	....
Nails, bolts, nuts, washers	ton	70.00	—	80.00
Tool steels, special alloys	ton	300.00	—	500.00
Bessemer pig iron	ton	32.00	—	35.20
Bessemer steel	ton	43.50	—	47.50
No. 2 foundry	ton	37.90	—	....
Steel billets (4 x 4)	ton	47.50	—	....

POWER HOUSE SUPPLIES

Steam packing, rubber duck	lb.	.99	—	1.10
Asbestos, high pressure	lb.	1.76	—	....
Asbestos, wired	lb.	1.30	—	....
Asbestos, graphited braid	lb.	1.21	—	....
Asbestos, wick	lb.	.75	—	....
Rubber, sheet	lb.	.66	—	....
Cup grease	lb.	.07	—	....
Transmission grease	lb.	.07	—	....
Axle grease	lb.	.04½	—	....
Gear grease	lb.	.04½	—	....
Cotton waste	lb.	.08	—	.11
Hose, underwriters, 2½ in.	ft.	.75	—	....
Hose, air, ¾ in.	ft.	.50	—	.60

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Arizona

DUNDEE—The Dundee-Arizona Copper Co. will build a treatment plant. A. J. Smith, secretary.

JEROME—The Shea Copper Co. will build its own concentrator in 1919. D. J. Shea, manager.

WALKER—The Black Diamond Mining & Development Co. will build a milling plant at its properties. C. N. Brown, manager.

Arkansas

MORRILLTON—The Commissioners of Sewer District No. 2 have awarded the contract for the construction of a sewer, involving 15,900 lin. ft. pipe, septic tank, etc., to S. R. Morgan & Co., Little Rock. Estimated cost, $16,000.

California

BISHOP—The Montezuma Mines will install a concentrator for water and oil flotation concentration at its mine about six miles east of Big Pine. Estimated cost, $30,000. A. Del Mar, superintendent.

LOS ANGELES—The Globe Grain & Milling Co., 901 East 3rd St., has awarded the contract for the construction of two 40 x 80 ft. and 40 x 60 ft. concrete buildings at 51st St. and Santa Fe Ave., for a hydrogen and oxygen plant, to Leonordt & Peck, 721 H. W. Hellman Building. Estimated cost, $25,000.

LOS ANGELES—The Los Angeles Graphite Co. will build a reduction plant for recovering graphite from Crescenta Canada tract, near here.

SACRAMENTO—The City Commissioners plan an election in April to vote on $1,883,000 bond issue, $1,200,000 of which will be used for the construction of a filtration plant. Thomas Coulter, commissioner of public works.

SAN FRANCISCO—The General Bond & Share Co., recently organized with a capital of $10,000,000, will develop a 1200-acre lease of potash properties in the Searles Lake district. Plans include the construction of a large refinery. B. Schlesinger, First National Bank Building, secretary.

SAWTELLE—The Board of Public Works, Los Angeles, will install a modern septic sewerage plant to handle the sewage here. W. T. Knowlton, engineer.

Colorado

PUEBLO—The Midwest Refining Co., First National Bank Building, Denver, will build an oil refinery here.

Connecticut

BRIDGEPORT—Charles C. Fisher, Asylum St., will rebuild and equip the garbage disposal plant recently destroyed by fire, entailing a loss of $25,000.

Florida

KEY WEST—The Bureau of Yards & Docks, Navy Department, Washington, D. C., received only one bid for the construction of a photo-laboratory here—from Ward & Pride, 307 Bisbee Building, Jacksonville, $6,792. Noted Dec. 30.

Idaho

MULLAN—The Copper King Mining & Smelting Co. plans new development work at its local properties, to include the construction of a 50-ton mill. Estimated cost, $25,000.

WALLACE—The Nabob Consolidated Mining Co. will build a concentrator having a capacity of 150 tons.

Iowa

MASON CITY—The city will build an experimental plant for the purpose of extracting the grease at the disposal plant, M. Conklin, chemist.

Kansas

PARSONS—The Missouri, Kansas & Texas R.R. will install a filtration plant at its yards near here. J. J. Johntz, engineer, has completed plans for the work.

Kentucky

PADUCAH—The Diamond Fluorspar Co., 129 South 4th St., recently incorporated with a capital of $99,000, will develop, 119 acres of fluorspar properties in this section to have an initial capacity of about five tons daily; equipment and machinery will be installed shortly. C. L. Van Meter, manager.

Maryland

CRISFIELD—The borough will build a sewage disposal plant and sewer. Estimated cost, $100,000. Norton, Bird & Whitman, Munsey Building, Baltimore, engineers.

SECURITY—The Security Cement & Lime Co., 125 West Washington St., will build a one-story, 50 x 50 ft. cement and lime plant. Total estimated cost, $20,000.

Michigan

DETROIT—Frederick Stearns & Co., Jefferson Ave., has had plans prepared for the construction of an eight-story, 100 x 110 ft. drug manufacturing plant, at Jefferson Ave. and Bellevue St. Albert Kahn, Marquette Building, architect. Noted Dec. 30.

WYANDOTTE—The city will soon award the contract for the construction of a filtration plant, having a capacity of 4,000,000 gallons. Estimated cost, $175,000. W. C. Lambert, mayor. Noted Aug. 15.

Minnesota

FAIRMONT—The city will receive bids in February or March for the construction of a 1,000,000 gallon water purification plant. E. L. Lewis, city clerk.

KEEWATIN—The village will build a sewage disposal plant. John Wilson, 300 First National Bank Building, Duluth, civil engineer, interested.

MINNEAPOLIS—The city will build a water-softening plant near the filtration plant. Estimated cost, $300,000. F. W. Cappelen, city engineer.

Montana

SALTESE—The Tarbox Mining Co. will build a concentrating mill. William Wallace, superintendent.

Nebraska

LAKESIDE—The Omaha Potash & Refining Co. will build a potash plant about twenty miles south of Lakeside. Estimated cost, $500,000.

New Jersey

JERSEY CITY—The Vulcan Iron Works, Morris St., has had plans prepared for the construction of a one-story addition to its plant on Essex St. Estimated cost, $8000.

New Mexico

CARRIZOZA—The Vera Cruz Leasing Co. will enlarge its existing mill to a 100-ton capacity and build a cyanide plant. R. B. Foster, president and manager.

Nevada

BATTLE MOUNTAIN—M. D. Farretta, Frank Childress and associates will place in operation a new 12-retort furnace for the reduction of cinnabar at their properties near here. John Ross, superintendent.

SEARCHLIGHT—The Big Casino Leasing Co. will build the first unit of its proposed plant; equipment, including two Deister-Overstrom roughing tables, a Herman ball mill flotation equipment and auxiliary apparatus, will be installed. F. E. Sharp, manager.

North Carolina

STANTONBURG—E. S. Darden and associates will establish an oil mill. Estimated cost, between $75,000 and $100,000.

Ohio

BELLAIRE—The Public Service Department has been authorized by the City Council to purchase one liquid chlorine machine for the filtration of the city waterworks. Estimated cost, $1000.

CLEVELAND—The Ohio Metal Briquetting Co., 909 Schofield Building, has awarded the contract for the construction of a one-story, 52 x 177 ft. factory at 401 Literary Rd., to Crowell-Lundoff-Little Co., 5116 Euclid Ave. Estimated cost, $30,000. Noted Nov. 15.

GENEVA—The city will build a sedimentation tank and filter bed for the waterworks plant. Estimated cost, $6000. W. C. Goddard, city engineer.

Pennsylvania

MEADVILLE—The city will build a sewage disposal plant, on the George Bosler farm.

South Dakota

DEADWOOD—The Standard Oil Co. will enlarge its plant here in the spring.

Tennessee

COPPERHILL—The Tennessee Copper Co., 61 Broadway, New York City, will build a milling and flotation plant, having a capacity of 1000 tons daily; plans include the construction of a granulating plant. Arthur L. Tuttle, general manager.

Texas

ARANSAS PASS—E. C. Ryan, Aransas Pass, has announced that New York and Boston capitalists will finance the construction of an oil refinery to have a capacity of 30,000 barrels per day at Harbor Island. The project will include the construction of a pipe line from Ranger, docks and coal and oil storage facilities. Cost will run to $15,000,000.

Virginia

HAMPTON—The Bureau of Yards & Docks, Navy Department, Washington, D. C., received only one bid for the construction of an oil storage and reclaiming building and a photographic laboratory at the Naval Air Station here—from R. R. Richardson & Co., Bank of Commerce Building, Norfolk, $28,445.

NORFOLK—The Norfolk Glass Manufacturing Co., 564 Church St., will soon award the contract for the construction of a one and two-story plant near Berkely St. Estimated cost, $200,000. Noted Dec. 30.

Washington

NEWPORT—The Bead Lake Copper Co. plans to build a new 100-ton concentrator at its properties on the Pend Orielle River.

Wisconsin

EAU CLAIRE—The Dells Paper & Pulp Co. has awarded the contract for the construction of a two-story paper mill to A. Larson & Co., 414 Main St.

HARTFORD—The International Steel Products Co., 1154 3rd St., Milwaukee, plans to build an addition to its factory in the spring. Estimated cost, $30,000. O. C. Unke, general manager.

MILWAUKEE—The Perfection Metal Co., organized by George E. Meredith and others with a capital of $99,000, will build a plant for the manufacturing and refining of metals.

MILWAUKEE—The Presto-O-Lite Co., 30 East 42nd St., New York City, N. Y., is receiving bids for the construction of a 1-story, 60 x 100 ft. compressor house for its branch filling station and service plant at 619 Trowbridge Ave. here.

British Columbia

ALERT BAY—The Beaver Cove Lumber & Pulp Co., Vancouver, will build a pulp and lumber mill. Estimated cost, $750,000.

LAKE BUNTZEN—The American Nitrogen Products Co., 905 Securities Building, Seattle, Wash., will build a chemical plant here. Estimated cost, $300,000.

SKIDEGATE—The South Eastern Mines will build a cyanide mill on gold property on Queen Charlotte Island which is being developed. A. S. Holmes, manager.

VANCOUVER—The Morrison Steel & Wire Co., Hawkes St., will rebuild its plant, which was recently destroyed by fire, entailing a loss of $100,000.

Ontario

COBALT—The Wright-Hargreaves Gold Mines, Ltd., will build a new mill and is in the market for machinery for same.

ELORA—The Elora White Lime Co. will build a new crusher plant and install machinery in same. Estimated cost, $60,000.

HAMILTON—The Steel Co. of Canada will build a benzol plant in connection with its coke ovens.

OTTAWA—The Honorary Advisory Council for Scientific and Industrial Research submitted report to Government recommending the construction of a four-story laboratory building to serve as a Central Research Institute. Estimated cost, $500,000.

SANDWICH—The Dominion Forge & Stamping Co. will build a new plant and install machinery in same. Estimated cost, $150,000. W. Herdegen, manager.

Quebec

CHICOUTIMI—Price Bros. & Co., 56 St. Peter St., will build a pulp mill. Estimated cost, $1,000,000. Sir William Price, 145 Grand Allee, president.

MONTREAL—The Pyrene Manufacturing Co. of Canada, Ltd., 3 St. Nicholas St., will build a factory. Estimated cost, $25,000.

TEMISKAMING—The Kippewa Fibre Co. has awarded the contract for the construction of twenty one-story, concrete buildings to be used as sulphite paper mills, to George A. Fuller Co., 45 St. Alexander St., Montreal. Estimated cost, $3,000,000.

THREE RIVERS—The St. Maurice Lumber Co., 2 Notre Dame St., will build a pulp and paper plant. Estimated cost, $500,000. R. F. Grant, manager.

Saskatchewan

HATTON—The Manitoba Jypsum Co., 504 Trust & Loan Building, Winnipeg, Man., will build a chemical plant here. Estimated cost, $40,000. William Main, president.

Industrial Notes

THE AMERICAN TRANSFORMER CO., Newark, N. J., has moved into an enlarged factory at 178-182 Emmet St., which is just a few blocks from its former location.

THE BROWN HOISTING MACHINERY CO., Cleveland, O., announces the following changes in its organization: Mr. Harvey H. Brown, chairman of the board of directors; Mr. Alexander C. Brown, president; Mr. Melvin Pattison, vice-president, general manager and director; Mr. Robert G. Clapp and Mr. John F. Price, directors, and Mr. Ewen C. Pierce, general manager of sales.

THE PERSOL CHEMICAL CORP., Buffalo, N. Y., has created and is marketing sodium hydroxide and potassium hydroxide in tablet form. These tablets are made up in the U. S. P. grade purified by alcohol and also in the C. P. grade made up in one and two grams and packed in one, two and five pound bottles.

THE NASSAU VALVE & PUMP CORP., Rockville Center, L. I., has moved into new and more commodious quarters in Rockville Center, where its facilities for quantity production of acid resisting valves and pumps of solid antimonial lead are materially increased. The more expeditious routing of production afforded by the better plant layout and an increase in machine space and machinery, as well as increased foundry facilities, and the addition to plant personnel of a number of experienced mechanics besides those already employed make this company fully prepared to handle the after-the-war business of equipping fertilizer, smelting, refining, dye and chemical companies with acid resisting valves and pumps.

THE LUDLUM STEEL COMPANY, Watervliet, N. Y., announces the following equipment now installed, either ready for operation or nearing completion: One 12,000-lb. steam hammer with 72-inch stroke, necessary crane and gantry rigging; one vertical water tube steam boiler working off of waste gases from the heating furnaces; two new heating furnaces to be used in conjunction with this new hammer; electric motor drive with Falk gear for the 10-in. mill, replacing one 800-hp. steam engine. The steam boilers used for this steam engine will be coupled up to existing steam hammer capacity and three additional 1000-lb. and 1500-lb. steam hammers. New grinding room has just been completed and 24 grinders installed, with another 12, making 36 in all, nearing completion. This grinding room will be used exclusively for grinding high speed steel billets. This grinding room will be fitted up with runways and other labor-saving appliances for quick handling of heavy material. Two additional 6-ton furnaces are nearing completion with an additional 10-ton crane. The new furnaces will be the Ludlum Electric Furnace Co.'s product. The total installation of electric furnaces at the Ludlum Steel Co. is now three 10-ton furnaces, three 5-ton furnaces and two 6-ton furnaces which have been made by the Ludlum Electric Furnace Corporation. A new annealing shop has just been completed containing six 15-ton annealing furnaces, and preparations are being made for the installing of two more of the same type of oil-burning furnaces.

THE NITRO PRODUCTS CO., Saginaw, Mich., is manufacturing naphthaline intermediates, specializing at the moment upon H-acid, for which they have equipment about completed to turn out regular and substantial quantities daily.

RICHARD K. MEADE & CO., Baltimore, Md., has moved its offices and laboratory from the Law Building to 11-13 E. Fayette Street.

THE ELECTRIC STEEL CO. of Indiana, Indianapolis, Ind., has been purchased by J. Rogers Halcomb and Roger B. Farquhar, Jr., formerly with the Midvale Steel Co. They will continue the business under the same name.

THE PHILADELPHIA ROLL & MACHINE Co., Philadelphia, Pa., has placed in operation a 25-ton acid open-hearth furnace. This company has also built a large pit annealing oven and a large core drying oven and is equipping the open-hearth building particularly for the manufacture of steel and steel alloy rolls.

THE SHARON STEEL HOOP Co. has started recently the No. 5 and No. 6 open-hearth furnaces in the battery at Lowellville, Mahoning County, Ohio. With the addition of these furnaces the monthly capacity of steel produced will be about 22,000 tons.

THE WESTERN RESEARCH CORP., 514-516 Eighteenth Street, Denver, Colo., has been organized by Carper, Ross & Co. and Mr. James M. McClave to handle the growing demand for industrial research and investigation. The business formerly conducted by Mr. McClave has been acquired by the new corporation and is to be greatly enlarged. A reasearch laboratory is fully equipped to solve all problems in handling minerals, non-minerals, oil, etc., and develop efficient scientific methods of treatment, furnish reports on engineering, mining, metallurgical and chemical design and construction of mills and treatment plants, also development and financing of properties which have been investigated and approved.

THE BOOTH-HALL COMPANY, manufacturer of electric furnaces, Chicago, Ill., has placed in successful operation during the past few months the following steel melting furnaces: West Michigan Steel Foundry Co., Muskegon, Mich.: 3-ton basic-castings for naval gun carriages; Monroe Steel Castings Co., Monroe, Mich.: 1½-ton-acid-steel castings; Queen City Foundry Co., Denver, Colo.: ¾-ton-basic-steel castings for Emergency Fleet Corp.; New England Steel Castings Co., East Longmeadow, Mass.: 1½-ton-acid-steel castings. In addition to these furnaces, there is also a ¾-ton acid lined furnace in operation at the plant of the Duriron Castings Co., Dayton, Ohio, used for experimental work in the manufacture of duriron, and a 1½-ton furnace at the Avery plant, Peoria, Ill., basic, used for the manufacture of tractor castings.

THE WILPUTTE COKE OVEN CORPORATION, New York, N. Y., announces that the new by-product coke oven plant of the Steel Co. of Canada, at Hamilton, Ont., will soon be in full operation. The plant consists of eighty 13-ton Wilputte regenerative by-product coke ovens, arranged in two batteries of forty ovens each. The contract date of completion called for the first battery to be put in operation on Nov. 15, and in spite of all difficulties, due to abnormal conditions, the first battery was charged on the date stipulated in the contract. The installation is complete, including by-product plant, coal and coke handling, boiler plant, etc., and will have a capacity of approximately 500,000 tons of coal per annum. The plant was designed and constructed by the Wilputte Coke Oven Corporation, New York.

THE ELECTRIC FURNACE COMPANY, Alliance, Ohio, has closed a contract with the Braeburn Steel Co., Braeburn, Pa., for a large continuous recuperative annealing furnace, for the annealing of alloy steel bars and wire. This furnace will have a capacity for annealing 75 tons per day, and an electrical capacity of 600 kw. One of the special features is that the material is heated and cooled slowly and owing to the fact that it is a special alloy steel must be soaked for a considerable time at a maximum temperature without scaling and without the use of the usual annealing box covers.

THE VANADIUM-ALLOYS STEEL CO., of Pittsburgh and Latrobe, Pa., manufacturers of high speed and alloy tool steels, have leased the offices and warerooms at 566-568 West Randolph Street, Chicago, Ill. This company will carry in Chicago a large stock of "red cut superior" high speed steel in all the standard sizes and shapes of bar stock, also treated bits for tool holders. Owing to the size of its new warerooms this company will now carry a much larger stock than formerly with which to serve Chicago and contiguous territory.

THE WELLMAN-SEAVER-MORGAN COMPANY of Cleveland, Ohio, has opened a San Francisco office at 415-417 Rialto Building, in charge of Norman S. Ross. Business originating from California, Nevada west of the 115th meridian, Lower California and the counties of Josephine, Jackson and Klamath in Oregon will receive the prompt attention of Mr. Ross.

MARDEN, ORTH & HASTINGS CORPORATION opened a new office in the Syndicate Trust Building, St. Louis, on Jan. 2, which is the eleventh branch of this corporation. The company's head office is at 136 Liberty Street, New York City. Mr. Lewis, who was formerly connected with the Chicago branch of the corporation, will have charge of the sales of chemicals, oils, dyestuffs and intermediates and tanning materials. The edible oil departments will be in charge of Mr. Schnabel, who was formerly in charge of the same departments at the Louisville branch. The St. Louis office has been opened for the greater convenience of the many customers of the corporation in Missouri and adjoining states, who will receive prompter attention by directing all inquiries to the new office.

THE INTERNATIONAL OXYGEN CO. announces the removal of its general offices from 115 Broadway, New York, to the company's Waverly works at 796 Frelinghuysen Ave., Newark, New Jersey. This centralization of the executive, sales and production departments at one point is made in order better to serve the interests of the company's trade.

New Publications

VOCATIONAL EDUCATION FOR FOREIGN TRADE AND SHIPPING. Bulletin No. 24, Commercial Education Series No. 2 issued by the Federal Board for Vocational Education, Washington, D. C. Dated, November, 1918.

CALIFORNIA MINERAL PRODUCTION FOR 1917 WITH COUNTY MAPS. By Walter W. Bradley. Bulletin No. 83, dated August, 1918, issued by the California State Mining Bureau, San Francisco, Calif.

HYDRAULIC EXPERIMENTS WITH VALVES, ORIFICES, HOSE, NOZZLES, AND ORIFICE BUCKETS. By Arthur N. Talbot, Fred B. Seely, Virgil R. Fleming, and Melvin L. Enger is Bulletin No. 105, Vol. XV, No. 37, dated May 13, 1918, and can be procured from the Engineering Experiment Station, University of Illinois, Urbana, Ill., for 35c.

ANNUAL REPORT OF THE DIRECTOR BUREAU OF STANDARDS TO THE SECRETARY OF COMMERCE FOR THE FISCAL YEAR ENDED June 30, 1918. Issued from the Government Printing Office, Washington, D. C.

ANNUAL REPORT OF THE CHIEF OF BUREAU OF FOREIGN AND DOMESTIC COMMERCE TO THE SECRETARY OF COMMERCE FOR THE FISCAL YEAR ENDED JUNE 30, 1918. Issued by the Government Printing Office, Washington, D. C.

NATURAL GAS: ITS PRODUCTION, SERVICE AND CONSERVATION. By Samuel S. Wyer of Columbus, Ohio. Bulletin 102, Part 7, issued by the Smithsonin Institution, United States National Museum, Washington, D. C.

NEW BUREAU OF MINES PUBLICATIONS: Bull. 157: Innovations in the Metallurgy of Lead. By D. A. Lyon and O. C. Ralston; Tech. Paper 192: Production of Explosives in the United States During the Calendar Year 1917. By A. H. Fay; Tech. Paper 206: Coke-oven Accidents in the United States During the Calendar Year 1917. By A. H. Fay; Bull. 129: The Fusibility of Coal Ash and the Determination of the Softening Temperature. By A. C. Fieldner, Albert E. Hall and Alexander L. Field; Tech. Paper 190: Methane Accumulations from Interrupted Ventilation in Coal Mines. By H. I. Smith and R. J. Hamon; Miners' Safety and Health Almanac for 1919, published in coöperation with the U. S. Public Health Service Compiled by R. C. Williams; Eighth Annual Report by the Director of the Bureau of Mines to the Secretary of the Interior for the Fiscal Year Ended June 30, 1918.

Published SEMI-MONTHLY *on the* FIRST *and* FIFTEENTH *of each month*

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

McGRAW-HILL COMPANY, INC.
Tenth Avenue at 36th Street
NEW YORK

JAMES H. McGRAW, President
ARTHUR J. BALDWIN, Vice President E. J. MEHREN, Vice President
EDWARD CALDWELL, Treasurer JAMES H. McGRAW, JR., Secretary

TELEPHONE, 2840 Greeley. CABLE ADDRESS, Machinist, New York

WASHINGTON, Colorado Bldg. SALT LAKE CITY, Newhouse Bldg.
CHICAGO, Old Colony Bldg. PHILADELPHIA, Real Estate Trust Bldg.
SAN FRANCISCO, Rialto Bldg. CLEVELAND, Leader-News Bldg.
LONDON, Hastings House, Norfolk St., Strand.

H. C. PARMELEE, Editor
ELLWOOD HENDRICK, Consulting Editor
ERNEST E. THUM, Western Editor
WALLACE SAVAGE, Assistant Editor

J. MALCOLM MUIR, Manager

Yearly Subscription price for United States, Mexico and United States dependencies, $3; all other countries, $4. Single Copy, 25c.

When change of address is ordered, the NEW and the OLD addresses must be given. Notice must be received at least 10 days before change takes place. No back copies for more than three months.

Copyright, McGraw-Hill Co., Inc., 1919. Entered as second-class matter July 13, 1918, at the Post Office at New York, N. Y., under the Act of Congress of March 3, 1879.

Circulation of this issue 12,000 *copies*

CONTENTS *for* February 1, 1919

Volume 20, *Number* 3

EDITORIAL
What of Industrial Opportunities in France? 97
Scrapping War Chemicals 97
Teach Engineering Students How to Study—First 98
The Iron Map of Europe 99

New Jersey Chemical Society 100
Annual Meeting of the Chemical Alliance 100
Importation Restrictions Removed by the War Trade Board 100
Sale of Surplus Materials and Scrap by the Ordnance Dept. 101
Little Platinum in Black Sands 101
New York Meeting of the American Institute of Mining Engineers 101
Perkin Medal Presented to Frederick G. Cottrell 102
Perkin Medal Presentation Address. By *Charles F. Chandler* 102
Commercial Production of Helium. By *Frederick G. Cottrell* 104
Engineering Council Establishes National Service Committee 114
Chicago Meeting of the American Institute of Chemical Engineers 115
Our Chemical Industries Made Permanent. By *G. W. Thompson* 118
Notes on a War-Time Trip to Europe. By *H. C. Parmelee* 124
Synopsis of Chemical and Metallurgical Literature 135
Convention of National Foreign Trade Council 136
Imports and Exports of Gold and Silver 136
Employees of Copper Companies to Meet Secretary of Labor 136
Meeting of the Canadian Mining Institute 136
Book Reviews 136
Personals 136
Obituary 137
Current Market Reports—Non-Ferrous Metal Market, Iron and Steel Market, Chemical Market and Chemical Price List 137
Industrial News—Plant Construction, Coming Meetings and Events, Catalogs, New Publications and Industrial News 142

What of Industrial Opportunities in France?

LIVE American manufacturers are speculating on the prospect of selling equipment and apparatus for reconstruction of industrial communities in Belgium and France. Naturally there is more or less groping about in darkness, but that condition is not confined to our manufacturers—even the French have not formulated their plans and they are in some confusion as to where to begin. The task is stupendous.

A few fundamental observations may be helpful. In the first place the devastated areas of France and Belgium must be reconstituted, beginning with that unit of society, the family. Scattered members of families must be brought together. Whether these families will then return to their former homes depends on whether the cities shall be rebuilt, and this in turn may hinge on the extent to which the industries once existing there have been re-established elsewhere. This may mean that existing communities will assume greater importance than some of those already destroyed. In any event the first problem is one of housing and food for the war-stricken people.

One obstacle to discovering what France needs is that no survey has been made to strike a balance between what has been destroyed and what has been replaced. The former is known quite well—the latter almost not at all. It seems as though our Department of Commerce should make or assist in making such a survey in the interest of our manufacturers. A difficulty is the scarcity of competent men. Another plan would be for associations of manufacturers to make their own surveys, sharing the expense. Individual concerns, of course, can cultivate the ground in their own private interest.

Something of that sort is necessary as a preliminary. France has not been conspicuous as an industrial nation, and there is no reason to assume that she will be. Perhaps the American manufacturer has little to look for in the way of European business and should turn his attention to South America. Certainly at present he should go slowly and investigate carefully. Some good advice is to be found in *Commerce Reports* for January 6 and 15, 1919, and August 27, 1918, which we commend to our readers.

Scrapping War Chemicals

EVERY once in a while we read that 280 carloads of TNT or hundreds of tons of mustard gas or an illimitable amount of phosgene or an infinity of chlorine has been dumped into the sea or is about to be cast into it. We have no actual confirmation of these harbingers

of destruction as final orders, but their persistence indicates that in the minds of too many unchemical Colonels and mystical Majors the idea prevails that chemical munitions should be destroyed because they were designed for a purpose which has ceased to exist. In this connection we do not refer to any unavoidable hazards to life, health or limb. Of course, these should be removed without cheese-paring in regard to the costs. What we object to is the sudden cessation of research, as though, now that the war is over, we do not need chemists or chemistry any more; or as though the job, being, as we hope, finished, everything should be scrapped or destroyed. This offends our business sense.

Our British cousins are keeping not only their scientific men but also those of signal ability in the administration of affairs at their posts, to aid in reconstruction. Our own Government, on the other hand, is letting too many of its valuable corps return to scholastic and industrial life.

If the rumors are true, it would be just as reasonable to throw the steel and other metals designed for use in shells into Chesapeake Bay because they will not be needed for war purposes. It has taken vast wealth and labor to prepare the store of war gases, and if the Ordnance Department does not know what to do with them, we suggest that the very able chemical staff which has accomplished so much in devising methods to prepare them be called upon to find new uses in the arts of peace. If, however, the War Department cannot bring itself to maintain its chemical service, there is the Bureau of Mines, which is a permanent institution. Although it is under the control of the Department of the Interior, Secretary LANE is not a man to be worried by red tape. Director MANNING has wisdom and understanding and we should cease to be anxious if the disposal of these things were placed in his hands. The chemical staff of the Bureau under Dr. PARSONS is not only exceedingly able and efficient but also thoroughly well administered. It has the facilities for research, and we hold that research is sorely needed.

Property should not be destroyed because it is a drug on the market. That is always bad policy. True, the substances are poisonous, but so is sulphuric acid and so is nitric acid; yet neither of these is thrown away when the market grows dull. The alkali cyanides have a well-established reputation for being poisonous, but that does not prevent them from being used in the recovery of gold. It is not good practice to run sodium cyanide down the drain, for prudential as well as for economic reasons.

Chlorine is indeed a problem, and new uses are needed in connection with the electrolytic soda industry. Nevertheless we shall not grow wise by dumping it. Its use is a problem in research which may find its solution in sewage disposal, or in any one of a considerable number of applications in industry or sanitation. Why not get busy in the Government research laboratories before the stuff is thrown away and the plants are dismantled? It is quite possible that within a year's time we shall be demanding chlorine with all our might and main.

We understand that Colonel WALKER has found an excellent market for phosgene, aside from its use as a solvent for ferric oxide to bleach sand for the glass industry. Shall it nevertheless be destroyed because it was made with intent to kill? It looks as though there were some uncontrolled legal talent at work in the Ordnance Department, which, coupling the intent with the substance, concludes that, the purpose being *non est*, the substance also should be made *non est*. We suggest that the authorities make Colonel WALKER a General, so that he may speak with the voice of authority before the remaining official pundits give military expression to their opinions.

Teach Engineering Students How to Study—First

STARTING from the oft-expressed idea "Engineers are needed as never before," many ill-considered schemes are being proposed and in some cases instituted to increase the output of our technical schools. Reduce the content of courses, graduate the men in three or even two years, or get a greater number of matriculants, is the net effect of most of the proposals. It is common knowledge that an unduly large percentage of the present graduates cannot be called engineers, in the true meaning. Yet the thought which doubtless has been given toward increasing the supply of real engineers by decreasing this proportion has so far brought few tangible results.

The boys presenting themselves for college entrance are largely volunteers. As human material they would delight a leader's eye. Properly handled they should successfully attack extraordinary difficulties. Yet an unconscionable number fall by the way, far short of the desired goal, their failure in good measure being due to improper preparation.

The average high school graduate is notoriously a "lame duck." Some of them are lacking in the mental and moral stamina necessary to attack and solve problems honestly. The high school shrugs its shoulders and blames this on home environment and pre-school training. Few indeed there are who can express themselves in correct English, or who can use applied arithmetic with a fair degree of success. But the high school blames these shortcomings on the grammar school. Who, then, is to blame for the fact that the pupils slip through the "cultural" and "humanistic" studies of the high school curriculum and at the end do not know really how to study, much less how to think?

But technical schools are confronted with a condition, and while it may do some good to point out on whom the blame should rest, their immediate problem is to turn their volunteers into engineers. Here are boys applying for a job on a four-year contract. Their chief work will be to think and study; to study hard and honestly, to rearrange thoughtfully their accumulated store of elementary facts in the proper phalanx to attack more complex problems. Yet they do not know how to study and to think, and, unbelievable as it may seem, no one makes an effort to teach them these fundamentals. Naturally, they continue with boyish abandon their carefree attendance to forms, such as going to lectures and carrying books to their rooms; but at other times they link arms with a happy chum and joyously trust to the lucky star which has brought them thus far. Sooner or later they discover the startling revelation that life is not child's play and they have indeed wasted golden hours.

One might profitably draw an analogy from like problems arising in intensified shop production. Machines could be bought but no men found to operate them; to put an unskilled man at them would certainly ruin the material, probably damage the machine, and very possibly injure the workman. Yet under the care of a competent instructor, an intelligent person could be turned into a successful operator in a very few weeks. Intensified individual instruction in elementary details solved the problem of skilled labor shortage.

If the technical schools would first teach their freshmen how to study and how to think, they would recover the time spent tenfold in later courses. Turning unskilled boys loose in college has resulted in a compromise of academic ideals, damage to the reputation of higher education and in many cases ruin of the boy's future expectations. More engineers of a sort may be had by shorter courses, fewer vacations and examinations, but more engineers of sorts may be had by preliminary and intensive training in the fundamental work of studying and thinking.

The Iron Map of Europe

PIG iron and steel do not grow, they are made—a fact that seems to be overlooked by those who have already sketched the iron map of Europe that is to obtain in future. Apparently they assume that the restoration of "German Lorraine" to France means that a quantity of pig iron and steel production corresponding to the 21,100,000 tons of iron ore produced by the territory in both 1912 and 1913 will be subtracted from the German production and added to the French production. It does not follow that because the territory becomes French again there will be an increase in French production of pig iron equal to the tonnage of iron ore formerly produced in it, and an increase in French steel production corresponding with such increased quantity of pig iron. These commodities must be made, they do not grow. The iron ore will probably be mined as formerly, but it remains to be determined who will smelt it into pig iron and who will convert the pig iron into steel.

The habitat of the pig iron and steel production will not be decreed by the Peace Conference, except as it may establish certain principles and rules, dictated by taking cognizance of economic, financial, metallurgical and engineering considerations.

Before the war there was a very complicated movement of the Lorraine or "minette" ores. The ores were produced in French Lorraine, German Lorraine and Luxemburg, and were consumed by these three countries plus Belgium. Some of the ores have an excess of lime, some of silica, and thus a certain amount of interchange over international borders was dictated by metallurgical considerations, while Belgium had to be supplied *in toto*.

France, however, while importing only 500,000 tons of ore from German Lorraine, exported to Germany more than 2,000,000 tons, of which half was consumed in Westphalia and the other half in German Lorraine and the Saar district, being attracted thither in limited quantities by the fuel. For a time during the peace negotiations, by the way, a contingent of the French set up a claim for the Saar coal basin, as requisite for the working of the ore, but this claim has been abandoned. Westphalia also consumed nearly 3,000,000 tons of ore mined in German Lorraine, and some of the pig iron produced by the Germans in Lorraine went to other districts of Germany for conversion into steel, while in general there was a flow of steel to more interior points for further working.

One does not know what individuals will own the ore mines, blast furnaces and steel works now in the territory that is to be transferred from the German to the French flag, but there is one thing that every one ought to know, that all Europe has got to work hard for years, and hence that all work that is done must be along the best engineering and metallurgical lines. If iron ore, or pig iron, or unfinished steel, or finished rolled steel needs to cross the new international boundary in order to accomplish the best economic results, that movement will have to occur.

In 1913 France produced 4,686,866 metric tons of steel ingots and Germany 18,958,819 metric tons of steel ingots and castings, both outputs being new high records. It is a simple matter to assume that the restoration to France of the aggrandized portion of Lorraine will add a certain tonnage to the French figure and subtract from the German. The arithmetical computation has indeed been made, and noting that the British capacity, with the completion of some work now under way, will be 11,000,000 or posibly 12,000,000 tons, the observation has been made that the three countries will be almost evenly balanced in steel production.

The French have a great deal of work ahead of them and they are very short of man power, while their financial resources are limited. No country has exercised more care to conserve its credit than has France, but that probably means conservatism for the future. The French will be well content if they can find full employment for their man, and woman, power and their capital. They will not set any certain mark, of 5,000,000, or 7,500,000, or 10,000,000 tons of steel production to be accomplished, but will endeavor simply to employ all their resources to the best advantage. In French Lorraine the blast furnaces and steel works have been destroyed or greatly injured, while the iron ore mines are reported practically intact. Restoration is needed, and this may possibly take more than a year. Some new steel works have been built during the war, and undoubtedly these will continue in operation.

It is easy to say that France will have such and such a steel capacity after the adjustments are made and assume that production will be in accordance. It would be still easier to say that the capacity of the United States is 50,000,000 tons, and accordingly assume that the United States will produce 50,000,000 tons each year, but the difficulty there would be that we are not doing it, and are in no way to do it in the near future. The fact that France is far away does not justify our taking liberties. The thing will have to be worked out, and iron ore mined in France, in reunited Lorraine, will probably pass to Germany, probably also some pig iron and perhaps partly finished steel, just as large tonnages of ore will continue to move into Luxemburg and Belgium.

New Jersey Chemical Society

THE third regular meeting of the New Jersey Chemical Society was held in the Wistaria Room at Stetter's in Newark Monday evening, Jan. 13. The evening opened with a banquet attended by 100 members, which was followed by the first "Rubber Night," with an attendance of more than 200 members and guests. Following the plan adopted by Dr. Calvert of the program committee, there was a scientific paper, read by Mr. George D. Kratz of the Falls Rubber Co., Cuyahoga Falls, Ohio, on "The Effect of Certain Accelerators on the Vulcanization of Rubber," which we expect to publish in a later issue. The popular paper of the meeting was read by Dr. Frederic Dannerth of Newark and was entitled: "Some American Substitutes for Rubber, From the Viewpoint of the Investor and the General Consumer."

Dr. Dannerth differentiated between artificial rubber, imitation rubber, synthetic rubber and rubber substitutes. In fact, some importers, he said, were inclined to import resinous gums under the tariff paragraph of "india rubber, free." The question of rubber substitutes, he continued, is of great importance because it involves our national welfare, and because the finest grades and most valuable varieties of rubber grow entirely outside the mainland of the United States. It is therefore most necessary and desirable to make an industrial survey of American raw materials and products which come into consideration.

The speaker enumerated 17 groups of materials, including raw oils; fats and waxes of vegetable and animal origin; sulpho-chlorinated oil products, called white substitute; sulphurized oil products, generally known as black substitute; sulphonated oil products of the type of turkey red oil; pitches and solid hydrocarbons obtained from petroleum, coal tar, asphaltum and fatty acid distillation; synthetic resins of the condensite type; natural resins obtained from spruce in the Carolinas, guayule in Mexico and chicle in Central America; carbohydrates, including starch and sugar; water-insoluble soaps prepared from lead, magnesium, aluminium, zinc and calcium; animal proteins such as glue and casein of cow's milk; and, finally, gums related to rubber. These include guayule obtained in Mexico from the parthenium shrub and chicle obtained in Yucatan from the achras tree.

Dr. Dannerth emphasized the fact that rubber and cotton are today "key materials" for the rubber goods industry, and no pneumatic automobile tires are made without rubber and cotton. Long staple cottons are being cultivated today in Arizona and the Imperial Valley, but high-tensile rubber is entirely absent as a natural resource. Virtually all plantation rubber is brought from the East Indies, a distance of 8000 miles, or from Brazil, a distance of 3000 miles. The per capita annual consumption of rubber goods in the United States is about ten pounds, which means that each person uses or obtains the benefits of ten pounds of all kinds of manufactured rubber goods each year.

"Will the rubber plantation owners repeat the $3 rubber market performance of April, 1910?" This was the question brought up for consideration by the speaker, in view of the approaching declaration of peace. The speaker also called attention to the statement made by one of the large plantation owners in the New York Rubber Conference in 1912 to the effect that he could, if need be, deliver rubber in New York City at a price close to 25 cents per pound. The London *Times* was recently quoted as saying that 80 per cent of the plantation rubber acreage is now under British control. But, Dr. Dannerth said, this should only serve to show that the British recognize the importance of controlling "key materials."

It was stated that the consumption of rubber in the United States in 1917 was 330,653,600 lb. of raw rubber and our annual imports of guayule rubber from Mexico are about 5,100,000 lb. Synthetic or factory-made rubber is a reality, but the cost of manufacture has not been cut down low enough for use during times of peace. This is the only material which possesses the peculiar properties of natural rubber, namely, the ability to gain in tensile strength and elasticity to an enormous degree by the process of vulcanization. But the substitutes for rubber possess many properties which rubber does not possess.

Annual Meeting of the Chemical Alliance

The second annual meeting of the Chemical Alliance was held in New York Jan. 23 to 25, at which time the question of the future of the organization was considered. Superseding the advisory committee on chemicals of the Council of National Defense, the principal function of the Chemical Alliance was that of a war agency to assist the Government. The need of an organization representative of American chemical industry is quite as great now and in the future as it has been in the past. Three important problems must be solved. The first relates to the urgent need for the validation of war contracts which involved vast expenditures on the part of the industry, but which, under stress of war, were not legally executed. Fresh legislation should be enacted speedily to enable the Government to take care of its moral obligations. The second matter demanding consideration is the re-sale of material bought by the Government under war contracts and to be resold as soon as practicable. The third question refers to the possibility of expanding foreign trade in chemical products. The directors announced that they would support the continuance of this organization in its present form and when the matter was put to a vote at the general meeting, there was unanimous concurrence. A special committee appointed to study foreign trade is expected to report its findings within two months.

Importation Restrictions Removed by War Trade Board

The War Trade Board announces that previous restrictions upon importation of chromite, monazite sand, manganese ore, copper ores, copper concentrates, pyrites, graphite or plumbago and graphite crucibles have been removed and that licenses will be issued for the importation of these materials from any country. It is further announced that with the exception of pig tin, tin ore and concentrates, the supervision heretofore exercised by the War Trade Board through various associations in the several trades over the distribution of raw materials in this country has been removed.

Sale of Surplus Materials and Scrap by the Ordnance Department

ALL surplus, unused or obsolete construction and manufacturing materials, semi-finished and completed parts, miscellaneous supplies, etc., left over at time of cancellation or termination of Ordnance contracts, or surplus at arsenals and supply depots will be ordered sold or stored as conditions require by the subcommittee on sale of material of the Salvage Board. The actual sale of this material will be handled by the material branch of the stores and scrap section of the Ordnance Department through the district stores and scrap managers, located in each district Ordnance office.

Capt. Ralph C. Shaw, chief, material branch, located in Group B, Section 1, Room 303 of the Ordnance building, at Seventh and B Streets, Washington, D. C., is compiling lists of the materials to be disposed of as promptly as these materials are reported for sale. Likewise he is compiling lists of buyers of given classifications of materials. This information is being imparted to the district managers. Any Government agencies or others interested in the purchase of any materials having been or to be ordered sold by the Salvage Board should communicate with the material branch.

All scrap left over from the operation of Ordnance contracts will be sold by the scrap branch of the stores and scrap section, operating through the stores and scrap managers of the district Ordnance offices. This scrap consists of different kinds of steel in sheets, billets and turnings, scrap steel parts, cupro-nickel scrap, antimonial, lead dross, silk and cotton waste, burlap, spent acids, etc.

District representatives of the stores and scrap section can give information as to scrap available. Likewise Lieut. Schleck, chief, scrap branch, Group B, Section 1, Room 305, will be glad to advise as to amount of scrap on hand at any point, price at which it is being held, etc. He will also be glad to receive names of Government agencies or other possible buyers of these materials.

Plans for close co-operation between the Government and industry in the sale of surplus Government supplies are also being worked out by the director of sales of the War Department and the War Service Executive Committee of American Industries. The policy of the Government with respect to the sale of supplies, as outlined by C. W. Hare, director of sales, will be to consult representatives of the industries concerned whenever sales are to be made in volume likely to disturb trade conditions.

The War Service Executive Committee consists of the members of the executive committee of the Chamber of Commerce of the United States, with the addition of others to make it more completely representative of all the groups of American industry.

Little Platinum in Black Sands

THE Bureau of Mines recently investigated the black sands of the Pacific Coast to ascertain whether there was a possibility of obtaining platinum therefrom. The results of the investigation may be summarized by the statement that in general the black sand deposits are disappointing in both value and quantity; they rarely contain enough gold and platinum or occur in adequate quantity to be exploited at a profit. There are, it is true, a few favored places where small areas of the black sand show some precious-metal content, and these may become the site of small operations. The deposits in many places contain appreciable amounts of magnetite, chromite and ilmenite, but these minerals are generally too scattered and too poor to constitute an important source of iron ore, especially in competition with the known deposits of magnetite on the Pacific Coast.

The chief difficulties in the profitable exploitation of these deposits are, first, lack of uniformity in occurrence and metallic content, and, second, the high cost of mining and treating the materials.

Black-sand mining in the past has offered a fruitful field for unscrupulous promoters and has been especially alluring to men having little knowledge of mining or mining methods. These swindlers usually claim to have some wonderful machine or process for extracting gold and platinum from the sands. Many of these agents made the most extravagant claims for the processes or machines. Some of these process men were so bold as to claim that they could recover gold and platinum where it could not be detected by any known scientific method. As a result the Pacific Coast is strewn with the wrecks of many kinds of experimental machines and of plants that bear evidence to the credulity and childlike simplicity of those who had been induced to invest their money in schemes for treating the sands.

Technical Paper 196, "Notes on the Black Sand Deposits of Southern Oregon and Northern California," has just been issued by the Bureau of Mines.

Copies of this report may be obtained free by addressing the Director of the Bureau of Mines, Washington, D. C.

New York Meeting of the American Institute of Mining Engineers

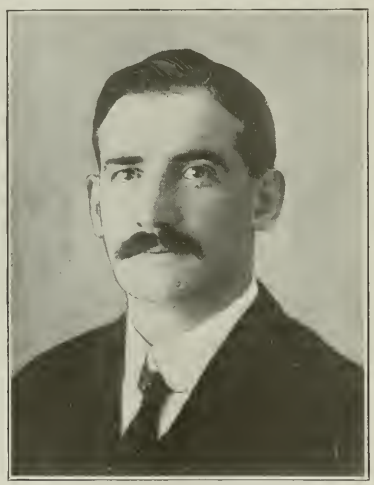
The one hundred and nineteenth meeting of the American Institute of Mining Engineers will be held at Institute headquarters, 29 West 39th Street, New York City, Feb. 17 to 20, inclusive. Technical sessions will be devoted to non-ferrous metallurgy and metallography, conducted by the Institute of Metals Division; industrial organizations; petroleum and gas; iron and steel; mining, milling and geology; coal; and electric welding, the last being considered at a joint session with the American Institute of Electrical Engineers. Tuesday, Feb. 18, has been designated as Canadian Mining Institute day, at which time there will be a discussion of international co-operation in mining in North America and uniform mining law for North America. A session of the National Research Council will be held Wednesday, Feb. 19, and on Thursday, Feb. 20, there will be an all-day excursion to the plant of the Federal Shipbuilding Co. at Newark, N. J., for the inspection of electrical welding of ships. Luncheon will be served each day at Institute headquarters. Social features of the meeting are a smoker, a travelogue by George Miller Dyott, late of the Royal Naval Air Service, and the annual banquet at the Hotel Biltmore. Special entertainment for ladies has been provided for by the Woman's Auxiliary.

Perkin Medal Presented to Frederick G. Cottrell

Award Made for the Recipient's Work in the Electrical Precipitation of Suspended Particles in Gases—Dr. Cottrell Describes Recent Work in the Commercial Production of Helium for Use in Balloons

THE thirteenth impression of the Perkin medal was presented to Dr. Frederick Gardner Cottrell, chief metallurgist of the U. S. Bureau of Mines, at a meeting of the New York Section of the Society of Chemical Industry on Friday evening, Jan. 17, at Rumford Hall. Major Charles E. Sholes, the honorary chairman, presided.

The hall was completely filled by an audience that represented a wide scope of chemical activity, both pure and applied, and messages of regret were read from the Secretary of the Interior, the Director of the Bureau of Mines, the Secretary of the Smithsonian Institution and others.



DR. FREDERICK G. COTTRELL

Joint Meetings Discontinued

Chairman Sholes announced that the joint meetings with the New York Section of the American Chemical Society, which the pressure of war-time conditions had made necessary, would be discontinued and that the meeting of the Society of Chemical Industry scheduled for April would be held as originally planned. On that occasion there will be made the first award of the Grasselli medal, founded by the corporation of that name and to be awarded each year for the best thesis which, in the opinion of the committee, suggests or records the newest or best helps or accomplishments in applied chemistry. The vice-chairman, Dr. Parker C. McIlhiney, offered a resolution of felicitation on the close of the war to be sent to the parent society, which was duly adopted.

Mr. Charles H. McDowell, the recent chief of the chemical division of the War Industries Board, spoke briefly of the satisfactory way in which the chemical industry of the country played its part in the war, and the fine spirit of co-operation shown by chemists and chemical engineers in meeting emergencies. The result was that our chemical accomplishment excelled that of many other industries.

Major Sholes' Remarks

Major Charles E. Sholes, chairman of the New York Section, in his introductory remarks said:

"Of course, it is always an honor and privilege to serve one's country anywhere. But the public seems to think that at least during this war it was not such a great honor to have served in Washington. Every man I know applied for field service abroad and was promised it and was bitterly disappointed not to get it.

"I suppose the answer is that some one had to arrange for the food, clothing, guns, powder, ships, etc., and to keep the books—and be the goat. So we have been striving to be very good goats. But it is perhaps fortunate that the men now in Washington have the saving sense of humor, else they could not have worked so hard and cheerily and proudly at their jobs. Just now they are telling a story of fifty years hence when our grandchildren are discussing the present war, and Mary says to John, 'Was your grandfather in the great war?' John says, 'Yes, he was in the Ordnance Department.' And Mary says, 'So was my grandmother!'

Pleased at the Honor

"Perhaps it is through such view of service in Washington that many of us are rather astonished and particularly pleased when any one in Washington is publicly honored—and gets away with it. So it is a great pleasure for me to ask the senior past president of the society, Dr. Chandler, to address Dr. Cottrell of the Bureau of Mines in Washington, D. C., and present the Perkin medal."

Dr. Chandler, who had previously received an ovation when he entered the hall, reviewed Dr. Cottrell's life and work, and presented the medal. His address follows:

Perkin Medal Presentation Address

By C. F. Chandler

"Mr Chairman and Brother Chemists:

"It is my privilege and very pleasant duty, as senior past president of the Society of Chemical Industry residing in this country, to present to Frederick Gardner Cottrell, B. S., A. M., Ph. D., the thirteenth impression of the Perkin medal, in recognition of his most original and valuable work in applied chemistry.

"Dr. Cottrell was born in San Francisco in 1877, where he received his early education. His degree of bachelor of science was conferred upon him by the University of California in 1896. He continued his scientific studies at the University of Leipsic, graduating in 1902 with the degree of doctor of philosophy.

"Returning at once to America, he became instructor in physical chemistry at the University of California,

later assistant professor. This position he held till 1911, when he joined the staff of the Bureau of Mines in Washington. Here he was at first the consulting chemist, then successively chief of physical chemistry, chief chemist, and finally chief metallurgist, which position he still holds.

"After graduating at the University of California, he continued his work there, devoting his attention to studies of hydriodic acid, liquid and gaseous, which enabled him to increase greatly our knowledge of the physical and chemical properties of this substance. His papers on this subject were published in the *Journal* of the American Chemical Society, 1896 and 1899, and in the *Journal of Physical Chemistry* in 1898.

"In 1900 he published a very elaborate investigation on manganous sulphate in the *Journal of Physical Chemistry.* This investigation was made with a view to throwing light upon the very interesting case of equilibrium in systems of manganous sulphate and water. His first publications while in Germany related to the genesis of some of the double and triple salts of magnesium occurring in the Stassfurth saline deposits.

"Dr. Cottrell's inaugural dissertation was entitled 'The Residual Current of Galvanic Polarization Considered as a Problem of Diffusion.' It was published in 1903. From this date on he continued to publish reviews and investigations too numerous for me to refer to here. Specially interesting are papers on liquid air plants, 1905 and 1906.

His First Fundamental Experiment

"Dr. Cottrell's most elaborate and valuable investigations relate to electrical precipitation of particles of liquids and solids and began in 1906 with his work on sulphur trioxide fumes which are not easily absorbed by water. It had long been known that electric brush discharges caused fog to clear. Sir Oliver Lodge had worked along this line. Dr. Cottrell describes his first fundamental experiment on page 5 of his paper on 'The Electrical Precipitation of Suspended Particles,' published in the *Journal of Industrial and Engineering Chemistry,* August, 1911.

"As this shows the beginning of one of the most important contributions to industrial chemistry, I feel that I can afford to consume two or three minutes of the time allotted to me to quote this experiment, from Dr. Cottrell himself:

> It may be of interest to note that the clue to the solution of this difficulty came from an almost accidental observation. Working one evening in the twilight when the efficiency of the different points could be roughly judged by the pale luminous discharge from them, it was noticed that under the particular conditions employed at the time this glow became appreciable only when the points had approached the plates almost to within the distance for disruptive discharge, while at the same time a piece of cotton-covered magnet wire which carried the current from the transformer and commutator to the discharge electrodes, although widely separated from any conductor of opposite polarity, showed a beautiful uniform purple glow along its whole length. The explanation lay in the fact that every loose fiber of the cotton insulation, although a relatively poor conductor compared to a metallic point, was still sufficiently conductive from its natural hygroscopic moisture to act as a discharge point for this high potential current, and its fineness and sharpness, of course, far exceeded that of the sharpest needle or thinnest metallic wire. Acting on this suggestion, it was found that a piece of this cotton-covered wire when used as a discharge electrode at ordinary temperature proved far more effective in precipitating the sulphuric acid mists, which were then the object of study, than any system of metallic points which it had been possible to construct. Perhaps the greatest advantage thus gained lay in the less accurate spacing demanded between the electrodes of opposite polarity in order to secure a reasonably uniform discharge.

"The first installation of his system was made at the Hercules powder plant at Pinoli, Cal., where there was a small contact sulphuric acid plant. There he used a 20,000-volt alternating current, rectified into a direct current by a motor-driven contact apparatus, and sent this current, by means of pubescent (hairy) asbestos electrodes, through the wet sulphur trioxide fumes and obtained precipitation.

Eliminating Fumes From Smelter

"This process, though successful, was not sufficiently profitable to warrant extensive use. It would probably have died had it not been that the nearby Selby smelter was in trouble. This smelter had a large plant near one of the tunnels of the Southern Pacific Railroad, and with certain winds the fumes of sulphur trioxide from the silver dissolving house would fill this tunnel with choking fumes, and finally legal proceedings were started to close the smelter plant. At this juncture Dr. Cottrell erected a small electric plant which met the difficulty completely and is running today, yielding dilute sulphuric as a by-product.

"But for the above-mentioned legal procedings the Cottrell process might never have materialized. The knowledge that fumes and smoke could be Cottrellized made the fume-pestered farmers all over the West sue the smelters right and left and satisfied the courts and juries that they were not asking the impossible of the smelters.

"The story of the Cottrell process for several years has been told in the news columns of the papers. Not alone has he taken the sting out of sulphuric acid waste fumes of smelters; he has brought down poisonous arsenic, saved metal dust otherwise going to waste, saved the orange groves from cement kiln smoke and recovered potash from that cement smoke to put on those very orange groves for fertilizer. The dust in the air, which was death to the trees through the clogging of the tender pores of their leaves, when duly Cottrellized and sacked and emptied on their roots, has given them new strength and life.

Extension of the Invention

"It would take a long time to give you a realizing idea of the marvelous extension of this Cottrellizing invention. I will content myself by giving you one example which I saw in the *Evening Post* of Jan. 11 last:

> Montana now has the tallest chimney-stack in the world, by a dozen feet, and in other dimensions it is immensely greater than its rivals. This is the recently completed stack of the Washoe reduction works of the Anaconda Copper Mining Co., which is 585 ft. 1½ in. in height. The outside diameter of the base, built in the form of a truncated octagonal pyramid, is 86 ft., and the walls are 5 ft. 4 in. thick at this point. The stack contains the equivalent of 6,672,214 common brick. Conducted through a vast flue system from the furnaces, the smoke will pass into chambers where will hang 111 miles of chains, electrified by a high-tension current. All the particles in the gases are electrified by contact as they pass through the links, and are vio-

lently repelled to be attracted by great plates between which the chains are suspended. These plates are grounded to form a negative pole. When they are thickly coated, the circulation will be diverted, the current shut off, and the accumulations will drop into hoppers.

"Dr. Cottrell's more recent work of investigation has had to do with the securing of helium gas for war balloons, which, being absolutely incombustible, is a wonderful substitute for inflammable hydrogen, while it is only slightly inferior in ascensional power. The helium is obtained from certain gas wells by liquefying out all the other constituent gases.

"I think I must cut my story short at this point and leave to Dr. Cottrell himself and Mr. Speed the pleasure of telling you of the Doctor's varied work at the Bureau of Mines and among the field experiment stations, as well as about the 'Research Corporation, an experiment in public administration of patent rights,' in which he takes such an active interest. I must say one more word: Dr. Cottrell has been granted many patents for his inventions and has generously donated them to the use of the public.

Conferring the Medal

"Frederick Gardner Cottrell, doctor of philosophy, my dear friend:

"It gives me the greatest pleasure, as the representative of the Affiliated Chemical and Electrochemical Societies of America, to place in your hands this beautiful Perkin medal, as a token of the appreciation and affection of your fellow chemists."

Cottrell's Work in Dewatering Oil

After Dr. Cottrell's speech of acceptance, printed in full elsewhere, Mr. Buckner Speed paid a tribute to Dr. Cottrell as follows:

"Dr. Cottrell has been, to those of us who have known him for the last fifteen years, a dear friend and gay companion. The fame and recognition that have come to him for the Cottrell process are less to us than the admiration we have for his unselfish character, his constant putting of his own interests entirely in the background and his remarkable imagination and his quick sympathy and helpfulness. On one occasion I remember his saying, at the completion of one of his larger pieces of work: 'Oh, I did not do much of it—I merely acted as a catalyzer to the boys who really did the work.' He has truly been a catalyzer to a host of us who have had the deep delight of working with him and coming in contact with his perennially fresh and keen imagination as well as his patience in the trying times that accompany all large efforts.

"This is the way the man's mind works: I recall some twelve years ago, when he was working on the precipitation of smelter smoke, I asked him for help on what seemed to be scarcely an allied problem—the freeing of California crude oil from its emulsified water. Instantly his mind worked with a snap: 'Why,' he said, 'it's the same problem. For air, put oil, for smoke particles, the minute water particles' and then his favorite form of expression: 'What will happen if we put a high electrostatic stress on the oil?' Then, in his characteristic quick manner, in a few minutes there were thrown together a beaker of oil, a spark coil and two pieces of copper, and lo! the de-emulsification of the California oils had been solved. Within a few minutes, on a block of paraffine under the microscope, there was spread out a drop of the emulsified oil, with two electric wires touching its edges. When the spark coil was put in operation the water drops were seen to arrange themselves in the field of the microscope like the iron filings between the poles of the magnet, to dance about and jiggle themselves into larger drops; and in these few minutes of experimentation the problem was solved by which millions of barrels of unmerchantable California oil were rendered fit both for refining and for fuel purposes.

"It was a familiar phrase to be heard in the University of California anywhere from the botany to the physiology departments when any question of any description came up: 'Oh, go over and talk to Cott about it—he doesn't know anything about the subject, but he will put some idea in your head before you have talked with him ten minutes,' and this he invariably did. This is the work he is now doing in Washington; and all over the country, wherever he touches an industry, there he leaves the germ of a thought that months later will come out as a manufacturing process. Such a man's work cannot well be measured by the achievements that have been credited to him."

Commercial Production of Helium

By Frederick G. Cottrell

MR. CHAIRMAN, Dr. Chandler, Ladies and Gentlemen: It is with a profound sense of appreciation on the one hand and of added responsibilities on the other that I accept this medal as a symbol of your approbation, friendship and confidence. I value the two former more than words can express, and this beautiful emblem will ever serve to keep clearly before me the responsibility to justify your confidence by striving to maintain unbroken the long line of high traditions of public service with which this award is associated on both sides of the ocean. I wish to thank you, Dr. Chandler, for this medal and for your kind words and, through you, the members of the awarding committee and the societies which they represent.

I am aware that it has been customary for the recipient of this honor to review the history of the subject particularly cited in the award, but the present year has witnessed the breaking of so many precedents and I have already on former occasions so thoroughly told you all that I know about electrical precipitation that tonight I shall take the liberty of dealing chiefly with quite another subject, though one which attracted my serious attention and study even earlier than electrical precipitation.

This is the industrial liquefaction and separation of the so-called permanent gases. My justification for this particular selection lies in the general interest at present in scientific problems whose solutions have been accelerated by the pressure of war needs, the case in point forming an interesting example in connection with the production of helium as a balloon gas.

Before turning to this, however, it may interest you if I briefly outline a few recent developments in administration of patents which, though not specifically referring to electrical precipitation, have to a certain degree perhaps been a by-product of the successful ad-

ministration of the precipitation patents by the Research Corporation.

Despite all the criticism which one hears of our American patent laws, I am disposed to look on them as remarkably satisfactory as far as they go and to feel that what is needed is not so much radical changes in the form and method of granting a patent as in the provisions for adequate administration, guidance and control in the interests of all concerned after it leaves the Patent Office.

Object of Research Corporation

The prime object to me in the formation of the Research Corporation was to furnish an experimental laboratory, as it were, in this most interesting branch of economics, and I have always looked upon the precipitation patents chiefly as mere kindling to start a fire under its boiler. If they have been able to generate some steam on their own account, it is of course gratifying, but that still does not distract my attention from the original aim.

The public's interest in the administration of patents has had surprisingly little attention when we compare it with other great problems of monopoly such as the railroads and the great fabric of corporate business. The patent laws as enacted in the early part of last century were entirely adequate to the simple structure of industry and economic life of the time, and it is amazing that they have functioned so well as they have through all the growing complexity ever since.

The attempt to work out in Congress sweeping reforms in the patent laws on the basis of our present knowledge would be a most difficult and even dangerous task, as well illustrated by the hearings on the Oldfields bill a few years ago. This is chiefly because we have little or no experimental data on what would happen if we tried by mandatory legislation to force at once on all patentees or their licensees and assignees new business methods which, although conceived in the most helpful spirit of fair play to all, would, when tried in practice, undoubtedly encounter innumerable unforeseen complications which might work great individual injustice besides actually hindering general industrial development. For this reason the somewhat unique sort of experimental work on patent administration purely in the public interest which the Research Corporation is doing appears highly important. Heretofore the study of patent questions has of necessity been approached almost wholly from the standpoint of one or other of the special interests concerned, such as that of the inventor, the patent bar or the large companies purchasing or operating under patents; while the broad, general interests of the whole public have not, as a rule, had the advantage of intensive continuous study and presentation by any agency wholly devoted to this purpose.

Interest in Patent Legislation

The most recent evidence of growing interest in this subject is a bill (S. 5265), introduced in the United States Senate on Jan. 2 by Senator Kirby, chairman of the Committee on Patents, which provides:

> That the Federal Trade Commission be, and hereby is, authorized and empowered to accept assignment of, or license under, to develop, to issue or refuse to issue licenses under, to encourage the industrial use and application of, and otherwise to administer, on behalf of the United States, under such regulations and in such manner as the President shall prescribe, inventions, patents, and patent rights which said commission deems it to the advantage of the public to be so accepted, as these may from time to time be tendered it by employees of the various departments or other establishments of the Government, or by other individuals or agencies; and to co-operate, as necessity may arise, with scientific or other agencies of the Government in the discharge of the duties herein set out.
>
> That the Federal Trade Commission be, and is hereby, authorized and empowered to collect fees and royalties for licensing said inventions, patents, and patent rights in such amounts and in such manner as the President shall direct, and shall deposit the same with the Treasurer of the United States; and of the total amount of such fees and royalties so deposited a certain percentum, to be determined by the President, shall be reserved, set aside, and appropriated as a special fund to be disbursed as directed by the President to remunerate inventors for such of their inventions, patents, and patent rights contemplated by this act as may prove meritorious and of public benefit.

This bill had its inception in the need felt for more adequate means of carrying the scientific developments made in the Government laboratories through to the public in their most useful and available form, and was sent as a suggestion in nearly its present form by Secretary Lane to President Wilson last August and referred by the President to the Federal Trade Commission for comment. During the war this latter body has administered enemy-owned patents in much the same manner and, therefore, already has much of the machinery and experience needed. The Commission, after careful study of the matter, reported favorably on the proposal, and one of the President's last acts before sailing for Europe was to send the bill with a strong recommendation to Chairman Smith of the Committee on Patents in the House, where hearings are soon to be held upon it. In the meantime, it has been introduced in the Senate to expedite its consideration by both houses. As the bill is attracting wide interest and no opposition seems to have developed from any quarter, its early passage is anticipated. This would be especially useful just now when the output of the Government's laboratories has been so increased by war activities and we are faced with the problem of dealing with many incidental discoveries and inventions coming therefrom, but having a predominantly peace-time significance.

What the Bill Contemplates

No matter how potentially valuable a purely scientific discovery is, it seldom benefits the public at large until it is carried through to industrial and commercial development and connected with the well-established avenues of trade. This is what the present bill is primarily intended to do. Incidentally also it automatically provides the expenses for its own administration as well as means whereby a modest pecuniary recompense may be awarded the discoverer or inventor of anything which through this channel eventually proves of material benefit to humanity. There are also signs of similar interest stirring in Canada and across the water, which it may be hoped presages a general and more active recognition of just these responsibilities on the part of government. It is, of course, particularly in the case of patents on broad fundamental projects that such an administration is of most importance to the public. The subjects both of electrical precipitation and that of liquefaction of

gases, to which we now turn, may excellently serve as suggestive examples.

The fact that my own connection with this latter work has been more from the administrative than the strictly technical or scientific side would make me hesitate to present it on the present occasion if it were not that looking back over the history of electrical precipitation a similar condition is evident, forcing me to the conclusion that even there my most useful services were in securing for the earlier fundamental suggestions of Sir Oliver Lodge and others the sympathetic consideration and practical large-scale development along lines of well-recognized engineering practice which they deserved but which had heretofore been lacking.

In 1904 it fell to my lot to set up and operate a liquid-air plant of the Hampton type at the University of California; and, in studying that installation, I became greatly impressed with the ultimate possibility of producing very cheap industrial oxygen by liquefaction and distillation of air, but was equally impressed with the very crude thermodynamics which, from a modern engineering standpoint, all the then common systems represented. Shortly thereafter I published two articles emphasizing some of these points and commenced experimental work along this line.[1] But pressure of other duties and lack of facilities prevented my carrying the latter very far. Ever since then, however, I have preached the importance of development in this field and have tried to follow up and post myself on each new attempt that came to my attention.

Quest for Cheap Oxygen

In assuming charge of the metallurgical division of the Bureau of Mines in 1916, it seemed that the quest for really cheap oxygen had become more than ever a large and legitimate part of my regular work; but, realizing my own limitations and the Bureau's inadequacy of material facilities, I strove to suggest, stimulate and collect inventions and developments rather than attempt to originate anything in this highly technical field.

In connection with the Bureau's laboratories at the International Exposition at San Francisco in 1915, we had already made a strenuous effort to interest the commercial oxygen companies in a co-operative experiment for the application of oxygen or enriched air to metallurgical furnace practice, largely in the hope of stimulating interest in the whole subject, but the project failed to receive sufficient support to be undertaken.

Oxygen as sold to-day in steel cylinders is so expensive that it usually fails to suggest even faintly the ultimate possibilities for low-cost production, in which latter case it would be of course simply piped at moderate pressure straight from the separating plant to the furnace. Thus, $200 a ton for even moderately pure oxygen is a very low price in steel cylinders to-day, whereas on the very large scale where unit cost of plant, overhead, sales expenses and the like are greatly reduced and compression into cylinders, transportation of same, etc., are completely eliminated, we come down to the power consumption for the actual separation as the largest and dominant factor of ultimate cost. Let us see what limits this sets. The individual steps in the process of liquefaction and separation of gaseous mixtures may all be made thermodynamically reversible to much the same extent in practice as are those of the steam engine and the air compressor. The chance for inventive skill lies chiefly in the selection of these individual steps from the alternatives long since clearly recognized and their combination into a consistent series. The difference in efficiency of present commercial processes resides in the acumen with which this choice and combination has been carried out and in the mechanical perfection of the apparatus in which the system is embodied.

The Problem

The final measure of theoretical efficiency is, of course, the degree to which reversibility in the thermodynamic sense has been approached. Air, for example, is only a mixture and not a chemical compound of oxygen and nitrogen and, therefore, no energy has to be supplied in its separation to overcome chemical affinity, but we do have to overcome what we may call the force of diffusion of the two gases in effecting their separation. In other words, we have to deal purely with that elusive second law of thermodynamics and not with the first. Thus, figured mechanically, the work necessary to separate five volumes of air at atmospheric pressure into one volume of oxygen and four volumes of nitrogen each at atmospheric pressure is simply that of bringing each of the partial pressures of the two gases as they existed in the mixture up separately to that of the original mixture. Or it is the work necessary to compress the oxygen from the five volumes at $\frac{1}{5}$ atmosphere to one volume at one atmosphere plus that to compress five volumes of nitrogen at $\frac{4}{5}$ atmosphere into four volumes at one atmosphere, all isothermally. Or, to put this even more concretely, if our heat interchanges and stills were thermodynamically perfect in their operation it would only be necessary to compress the original air isothermally to a pressure of approximately 10 lb. per square inch above atmospheric, to effect its complete separation into pure oxygen and pure nitrogen each at atmospheric pressure. Per ton of oxygen separated this figures out 60 hp.-hr. on the basis of isothermal compression. This is, of course, the theoretical limit for a perfect reversible cycle, which cannot be attained in practice, but we may hope to approach it to much the same degree that we have the corresponding limit in the steam engine and the air compressor, say 50 per cent as at least a legitimate goal for early endeavor. It seems doubtful whether any large scale air separating plants at present in service are greatly exceeding 10 per cent. But even 10 per cent would mean oxygen at a power cost of only 600 hp.-hr. per ton, which in itself should present startling possibilities to the minds of most chemists and metallurgists.

Magnitude of the Project

But why has there not been more actual development? This is chiefly due, I believe, to the very magnitude of the project, requiring as it does the closest co-operation and support of the whole undertaking from both

[1] "The Liquid Air Plant of the Chemistry Department, University of California," *California Journal of Technology*, Vol. 6, No. 1, pp. 1-11, Sept., 1905. "On Air Liquefiers," *Journal of Physical Chemistry*, Vol. 10, No. 4, pp. 264-274, April, 1905.

the users and producers of the oxygen. The transition from the present bottled oxygen stage of the industry to that of production directly at and as a part of the large metallurgical plant let us say where it is to be used means not only a complete redesign and development of larger production units but a complete reorganization of sales and business policy probably representing a licensing of equipment rather than manufacture and sale of product, a procedure which, to a well-established business concern, presents many drawbacks and dangers to its existing business. On this very account, the metallurgist on the other hand has never had the firm offer of oxygen in quantity and at a price to be within possible range of his operations except for such purposes de luxe as acetylene welding and burning out frozen tap holes; consequently he has never felt justified in the expensive development of oxygen or enriched air furnaces which, if successful, would in all probability necessitate very fundamental alterations in both equipment and practice.

Some Experiments in Belgium

Some experiments in this direction were indeed undertaken in Belgium before the outbreak of war, but were on an entirely inadequate scale to furnish conclusive results and, from the nature of the problem, its solution is bound to be an expensive undertaking, but one fully justified by the prospects of results attainable.

Let us consider for a moment the tremendous efforts already expended to concentrate up to the limit the ores and all the other raw materials entering a furnace and then remember that we are still adding the oxygen with four times its weight of inert nitrogen, all of which reduces the intensity of the chemical reactions and causes waste of valuable fuel, to say nothing of additional expenses due to excessive size of equipment.

But to return to the narrative. It was in March, 1916, that Director Manning of the Bureau of Mines handed me a memorandum of a conversation he had chanced to have in New York with some business men concerning a new process for air separation. The information had filtered through several non-technical hands until it had become more amusing than instructive; but, as it gave some definite addresses, I filed it with similar "clues to great inventions" and later tried to run it down to see if it had any foundation. The trail led me back with some little wandering to Mr. Fred E. Norton of Worcester, Mass., a graduate in 1891 of the Massachusetts Institute of Technology, who had since had responsible engineering experience pretty much all over the world, and I at once became interested in earnest.

Experiments Continued

His story for our present purpose begins with his leaving the position of chief designer of the turbine department at the Lynn works of the General Electric Co. in 1913, to enter the employ of Mr. E. A. W. Jefferies and undertake the engineering development of a process of air separation patented by the latter and which he had made arrangements with the General Chemical Co. to try out at one of their plants. After spending between $50,000 and $100,000 on this project the General Chemical Co. decided to drop it. Messrs. Jefferies and Norton then pooled their patents as the Jefferies-Norton process and, with the financial help of a few friends, continued experimental development in a smaller way for the next few years.

The parts of their process particularly attracting my attention were those Mr. Norton had introduced after cessation of the work at the General Chemical Co. and which radically changed the fundamental cycle upon which he in common with others had been working previously.

Scepticism Evidenced by Many

I found that, after making application for patents, they had discussed the work very freely with those who should be best able to judge of its merits and possibilities, but had made little progress toward securing practical and financial backing toward large-scale development. On attempting to investigate this situation, I found all sorts of impressions and rumors abroad as to just what the system really was. Many of those I talked with seemed to look upon it as a sort of perpetual motion scheme and were sure there was a flaw in the reasoning somewhere, although they had never run it down themselves, but understood that this one or that had done so. I had a good deal of work and not a little incidental amusement in following back to their source most of these clues and finally satisfied myself that if there really was anything fundamentally impossible in the cycle no one of those I was able to reach had been able as yet to put his finger on it.

Following our custom in the Bureau in such cases, an effort was made to put Mr. Norton and his associates in touch with people who might have sufficient use for such a process to justify their aiding in its further development, but for the reasons above cited I fully realized the difficulties and uncertainties in the way of definitely securing such co-operation.

Investigation in England

At the same time as the above development, but quite unknown to me, another thread of the present story was being spun in England. It so happened that Dr. R. B. Moore, now of the U. S. Bureau of Mines, had worked with Sir William Ramsey in his ever-memorable investigation on the rare gases of the atmosphere. Under date of Feb. 28, 1915, Sir William wrote to Dr. Moore:

"I have been investigating blowers, i.e., coal damp rushes of gas, for helium for our Government. There does not appear to be any in our English blowers, but I am getting samples from Canada and the States. The idea is to use helium for airships."

Importance of Helium for Airships

The importance of this proposed use of helium for balloons and particularly for airships of the Zeppelin type lies in the absolute inertness and non-inflammability of helium and the fact that it is of all known substances the next lightest to hydrogen, having about 92 per cent of the latter's buoyant effect. It also shows only about half the rate of diffusion and consequent wastage through the balloon fabric. As the fire hazard not only from incendiary bullets in war but also from atmospheric electricity and the Zeppelin's

power plant in both peace and war has constituted the greatest drawback to the development of lighter-than-air craft, it is difficult to overestimate what an available supply of this gas may eventually mean in the art.

At the time of the receipt of Sir William's letter the United States was not as yet in the war and nothing immediately came of the suggestion in this country. Dr. Moore remembered, however, that in 1907 Dr. H. P. Cady of the University of Kansas had found more than I per cent of helium in some natural gases from Kansas.

Dr. Moore's Letter

In a recent letter Dr. Moore says:

In April, 1917, when we entered the war, Sir William Ramsey was dead. Two or three weeks after war was declared, I attended a meeting of the American Chemical Society in Kansas City.[2] At the general session Mr. Seibel of the University of Kansas, who had been working with Dr. Cady, gave a paper on krypton and xenon in some of the natural gases of Kansas. At the end of his paper he expressed regret that at such a time, when every one was thinking of war problems, his paper was of a purely scientific nature and had no practical bearing on the war. I immediately got up and said that I did not agree with Mr. Seibel; as the presence of helium in these wells could, and should, have a very practical bearing on the war; as this gas could be extracted in quantity from the natural gas and used for balloons and Zeppelins. I pointed out some of the natural advantages of helium over hydrogen, and quoted Sir William Ramsey's letter. The general attitude of those present was one of scepticism, and I finally asked Dr. Cady for his opinion. He stated that he believed the thing could be actually done, but was very doubtful whether it could ever be made practical on account of the cost. At the close of the session Mr. Seibel came to me and asked if I really meant what I said, or whether I was joking, and I told him that I most certainly meant every word that I had said.

That same day I talked to Dr. Parsons, who was present at the meeting and who was returning to Washington almost immediately. I told him what had happened, and told him that I believed the matter should be taken up by the Bureau at once and presented to the War Department. He promised that he would do this as soon as he got to Washington; and I know that he did take the matter up with other Bureau officials.

News of Ramsey's suggestions also reached this country through other channels and eventually came to our attention. Professors Satterly and Patterson of the University of Toronto commenced experimentation on the subject Jan. I, 1916. Col. G. A. Burrell, who headed the research department of the Gas Warfare Service at the American University, tells me that Cady's experiments had also suggested similar possibilities to him.

U. S. Balloon Service Interested

However, no definite step toward securing action seems to have been taken in the United States until June 1, 1917, on which date Messrs. Moore and Burrell, at the time both of the Bureau of Mines, called on Colonel Chandler, in charge of the balloon service for the Army, and explained the whole subject to him. He was intensely interested, at once realizing its potentialities and asked that a report be made to him, giving all available details. He also took the matter up with Mr. G. O. Carter, in charge of hydrogen plants for the Navy, who had had several years' practical experience in the Linde Air Products Co. with the liquefaction and separation of gases by their process. Mr. Carter also immediately appreciated the importance of the subject and urged this upon the attention of his superiors in the Navy.

Up to this time in the whole world there had probably not been more than 100 cu.ft. of helium separated as a pure gas and its price in the small lots in which it was sold was at a rate of about $1700 per cu.ft.

About this time I was called into the conferences and was much impressed by the weight which the British Admiralty apparently laid upon the cost of separation of the gas as a determining factor in its practical availability. I was given to understand that they had figures on the basis of the well-known commercial processes of gas by liquefaction and separation and were unable to see how production could be hoped for at less than $60 to $80 per thousand cubic feet, which they felt to be practically prohibitive for the program they then had in mind. It was at this stage that I suggested turning to Mr. Norton at least for a plan and estimate of what he thought might be accomplished along the new lines he had been following, and we accordingly wired for him. On Monday, June 4, we spent practically the whole day in thrashing out the subject with Mr. Norton, Mr. T. B. Ford[3], then in charge of the low temperature laboratory at the Bureau of Standards, and Mr. O. P. Hood chief mechanical engineer of the Bureau of Mines. As a result, Mr. Norton was asked to act as a consulting engineer of the Bureau of Mines and prepare plans and estimates for an experimental plant.

Dr. Moore then returned to his station at Denver; shortly thereafter I left on a several months' circuit of our Western experiment stations, and the supervision of the project for the Bureau of Mines devolved entirely on Mr. Burrell.

Appropriation Made for Work

In due course a formal report made by the Bureau of Mines was transmitted through Secretary Lane to the War Department, and although this report was as yet fragmentary and based on very inadequate data concerning the practical conditions to be met in the field, the Aircraft Board, on July 31, 1917, recommended an allotment of $100,000, half each from the Army and Navy, which became available for the use of the Bureau of Mines on Aug. 4.

A detailed survey of field conditions, to determine the best available supply of natural gas for the purpose, was at once begun, as also the preparation of working drawings for the experimental separation plant.

The general supervision of this was for a short period at this time placed in the hands of Prof. W. H. Walker of the Massachusetts Institute of Technology, who had come to Washington to assist in the chemical warfare work. I believe it was his suggestion, for purposes of military secrecy, to use the word "argon," as a code term for helium, in all correspondence on the subject, it being thought that as real argon is also an inert gas, but too heavy to be of any value in balloons, and is already used to a large extent in the incandescent electric lamp industry, this would serve as

[2]April 10 to 14.

[3]Mr. Ford not only rendered valuable service in these early conferences but took a most helpful and important part throughout the later stages of the work, both at the Bureau of Standards and in a trip he made to the plants in Texas and was engaged on this work when suddenly stricken down a few months ago with influenza. His death came as a shock to us all, terminating as it did a career of great promise.

particularly effective camouflage. This has in fact so effectively confused the two words in the public's mind that it will take some little effort to clear up the situation, and I would therefore bespeak your help in holding strictly to the true name helium whenever referring to the subject, now that all secrecy in the matter has been abandoned.

Even though we had been drawn into this work primarily through the desire of the British authorities to find a more economic process than those already known to them, it was now felt that the project had taken on such magnitude that the whole field should be carefully canvassed *de novo*. Mr. Burrell therefore next communicated with the two well-established operating companies controlling, respectively, the Linde and Claude systems of gas liquefaction and distillation, to determine whether it would be possible to work out a plan of general co-operation and pooling of information and facilities for this specific war purpose. Due to questions of trade secrets and other business relations, this did not, however, prove practicable, though both companies expressed themselves as anxious to co-operate individually with the Government and entirely willing to undertake independently the erection of plants of their own respective designs at cost, or even less, and have ever since most cordially furnished every aid in their power to make the work as a whole a success.

British Send Commission

At this juncture a special commission from the British Admiralty, headed by Commander Cyprian D. C. Bridge, arrived in this country to collect data and exchange ideas on what was being done, and from the resulting conferences the possible importance of the work in hand became so evident that the Aircraft Board on Oct. 17, 1917, recommended that a further allotment of $500,000 be made jointly by the Army and Navy to permit of immediately starting construction of complete plants under all three processes.

In accordance therewith, Mr. Norton was directed to prepare plans for a somewhat more complete plant embodying his process than had originally been contemplated as a first step. This brought the total estimated cost of the plant to about $150,000.

Norton Project Sidetracked

In making the actual allotment, however, the Navy placed a restriction upon its half of the $500,000 that none of it should be used on the Norton project. When this was called to the attention of the Army the latter decided to follow the Navy's lead, as they were very largely relying upon it for guidance and had designated Mr. Carter to represent them jointly in the matter.

Thus, while thoroughly realizing the expediency of the Navy's policy in making sure that the plants under established processes should be adequately financed and pushed with all possible rapidity to completion, the curtailment of support for the newer and more experimental portion of the program was a disappointment to those of us in the Bureau of Mines who had made a careful study of the Norton project and felt strongly as to the importance of giving it a thorough trial. The representatives of the British Admiralty also stated frankly that their main interest lay in the experiments on this process, as there was no particular doubt in their minds that either of the other processes could produce the gas, the only question being one of cost, and on this no one responsibly connected with either of the two old processes had been willing to even hold out any definite hopes of producing helium below the cost of $80 a thousand cubic feet, which the Admiralty at that time considered prohibitive for its chief purposes. The matter was consequently taken up afresh with the Aircraft Board and after considerable discussion that body on Dec. 11 recommended to the Army and Navy a further joint appropriation of $100,000 specifically for the Norton project. The Army immediately acquiesced with regard to its half but the Secretary of the Navy, feeling the need of further outside advice in the matter, requested the National Research Council to investigate the project with special regard to its theoretical soundness and its apparent chances for practical success.

Committee Appointed

The Council appointed for this purpose a committee of five consisting of Prof. Harvey N. Davis of Harvard University, Drs. Edgar Buckingham and Charles W. Waidner of the Bureau of Standards, Dr. W. S. Landis of the Air Nitrates Corporation and Mr. S. L. G. Knox, consulting mechanical engineer and later scientific attaché of the American Embassy at Rome. This committee after very careful comparative study of the three processes concurred in the Aircraft Board's recommendation of the additional $100,000, which was then immediately made available by the Army and Navy.

This was early in February, 1918, the controversy over the support of the project having delayed the actual starting of construction on the Norton plant by something over two months.

In the meantime contracts had been closed with the Linde Air Products Co. and with the Air Reduction Co. for the construction and experimental operation of a Linde and a Claude plant respectively, each for an estimated daily production of about 7000 cu.ft. of helium, and construction was well along on each. These plants were to be located at North Fort Worth, Texas, and operate on a natural gas containing about 0.9 per cent by volume of helium and of which the Lone Star Gas Co. was bringing some 20,000,000 cu.ft. daily through its pipe line from the wells at Petrolia, more than a hundred miles northeast of Fort Worth, to that city for domestic and industrial consumption.

After careful study of field conditions it was decided to locate the Norton plant at Petrolia in direct proximity to the wells, a procedure which had not been deemed practical for the two other plants on account of their larger demands for power and water supply.

Other Investigations

Parallel with the Bureau of Mines work on processes of extraction, Dr. A. F. Rogers of the U. S. Geological Survey undertook a recognizance of all natural gas fields in the United States with regard to their possible helium supply, as this might be judged from sampling and analysis of existing wells combined with a study of geological conditions. As the results of this study are expected to soon be issued as a monograph by the Survey, no attempt will be made to deal with them here.

The Bureau of Standards also undertook the determination of certain physical properties of the gases. More especially the latent and specific heats and specific volumes of methane over a wide range of pressures and temperatures, and the diffusion of helium through balloon fabrics.

In order to co-ordinate properly all the different agencies concerned, the conduct of the helium work as a whole was about this time placed in the hands of a committee consisting of one representative from each of the three departments chiefly concerned. Mr. G. O. Carter, as chairman, represented the Navy, Dr. Harvey N. Davis the Army, and Mr. Geo. A. Orrok the Interior.

Quantity and Purity Increase

The Linde plant, costing in round figures $300,000, was the first to be contracted for and have its construction started. It commenced operation March 6 and on March 22 produced gas containing 28 per cent helium. By April 21 this purity had reached 50 per cent, the yield being at first small, but both quantity and purity steadily increased up to a maximum daily production on Sept. 6 of 7755 cu.ft. of 67 per cent purity, with average production of say 5000 cu.ft. at over 70 per cent purity, which was then further purified in a second step to about 92 or 93 per cent purity.

The Claude plant, costing about half as much as the Linde, commenced production some weeks later than the latter, and has also gradually increased its production and purity of product. Although up to date these are still considerably behind the performance of the Linde plant, a new still is just being installed at the Claude plant which it is hoped will materially improve both yield and purity of the product.

Due to present pipe line limitations coupled with heavy consumption of fuel gas at this time of year, it has been necessary for some months past for the Lone Star Gas Co. to substitute for part of the Petrolia gas some from other fields carrying less helium, so that the helium content of the gas at present being treated at Fort Worth has fallen to between 0.4 and 0.5 per cent by volume, which proportionately cuts down the production at both plants.

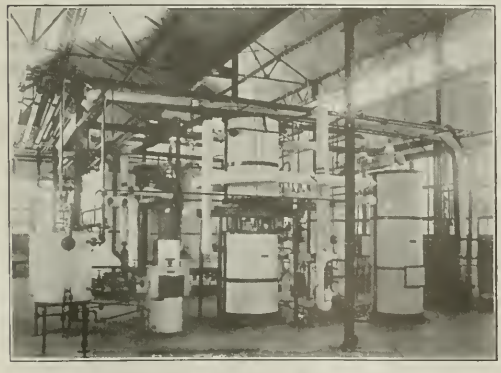
At the time of signing the armistice the first shipment of 147,000 cu.ft. of 93 per cent helium was on the dock about to be loaded aboard ship for Europe. This at the above-cited pre-war prices would represent about $250,000,000 worth of gas.

A large part of the credit for the promptness with which this actual production was affected is due to Mr. Carter, who was tireless in his efforts in pushing matters of priority, transportation, construction and production.

The Army and Navy have now jointly entered upon a larger production program under the immediate direction of the Navy, and have allotted some $5,000,000 for the purpose, including the construction of a new pipe line and additional units of the Linde plant at Fort Worth. General Squire, in an address before the American Institute of Electrical Engineers last week, stated that "Plants are under construction to give at least 50,000 cu.ft. a day at an estimated cost of not more than 10c. per cu.ft." If present expectations of the Norton process are fulfilled, this cost may be still further greatly reduced.

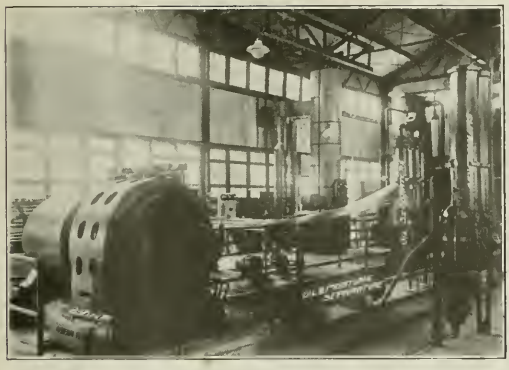
The Norton, or Bureau of Mines, plant at Petrolia was completed as far as initial construction is concerned the middle of October, and since that time its various parts have been successively undergoing tests and adjustments. The multi-tubular heat interchanges and large expansion engines, which were among the new departures in this plant, over which most anxiety was originally felt, have thus far worked out very well and now seem to be performing their allotted tasks to complete satisfaction. A good deal of difficulty was at first encountered by occasional floods of several barrels of oil and salt water coming over from the Lone Star Gas Co.'s gasoline extraction plant, which immediately clogged up the interchanges, making it necessary to shut down and go through the laborious process of thawing out the whole system and starting refrigeration afresh. This has now been eliminated by the installation of adequate settling chambers and traps, and tests and adjustments are proceeding upon the stills which form the last part of the equipment to be proven out. It is hoped that helium production will soon be attained, but as this plant has a rated production capacity of several times that of either of the other two, each change or adjustment in its parts requires rather more time even aside from the fact of the entire novelty and experimental character of many of its parts.

In studying the different systems of gas liquefaction

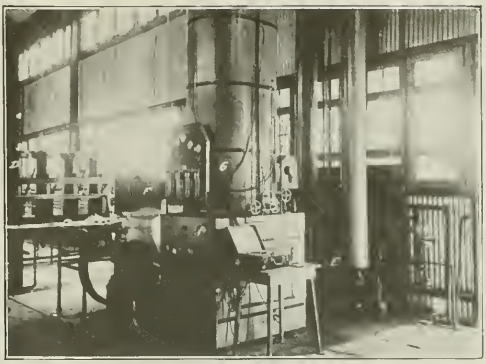


INTERCHANGE AND STILL ROOM OF LINDE PLANT

INTERIOR OF LINDE PLANT COMPRESSOR BUILDING



GENERAL VIEW OF THE CLAUDE PLANT AT FORT WORTH, TEXAS



D—HIGH PRESSURE PURIFIERS. E—HEAT INTERCHANGERS. F—EXPANSION ENGINE. G—STILL, ETC.

and separation it is very essential at the outset to distinguish clearly between the production of liquid as an ultimate product and the utilization of liquefaction and re-evaporation as a mere step in a separation where the ultimate products desired are still gases and at essentially the temperature of the original mixture fed to the apparatus.

In the former case a very considerable expenditure of work is represented in what we may colloquially term the refrigerative properties of the liquid delivered.

But in the second case, where the liquid is not drawn off from the apparatus and its amount therein remains constant, the part continually evaporating serves to condense nearly an equivalent amount of the incoming gases. Also the cold gases furnished by this evaporation take up heat from and cool the fresh incoming gas while they themselves are returning to room temperature.

Ideal Equal Pressure Process

Thus we may illustrate diagrammatically, as in Fig. 1[1], the continuous process of liquefaction and re-evaporation of a single gas. Ideal conditions would consist in perfect heat interchange horizontally between the two legs of the U tube A and C and perfect heat insulation lengthwise along each of these and from their surroundings.

If these conditions were fulfilled and the whole system once brought to a steady state by, let us say, refrigeration of the bottom of the U tube by some extraneous source of initial cooling while gas was slowly passed through it, we may imagine a certain amount of liquid condensed at the bottom of the U and a uniform gradient of temperature established along its two legs. Now, if the initial extraneous source of refrigeration were removed but gas still passed slowly into the system, the gas would progressively cool in A, liquefy at B, re-evaporate at B_2 and warm back to the atmospheric temperature in passing up C. Under these ideal conditions, with a single gas, the slightest imaginable difference in pressure between A and C should serve to perpetuate the process.

[1]The four cuts here shown are from a report made in the early part of this work by Mr. Norton to Mr. Burrell, outlining the problem in hand and the relation of the three processes to one another as they appeared to him.

Whatever heat leakage there is, however, either through the walls of the insulating chamber or down the legs of the U tube, represents a loss not of energy itself but of its availability for the purposes in hand; i. e., of thermodynamic potential, or an increase of entropy, if one prefers that terminology, the practical result being the necessity of expending mechanical work to compensate for these heat leaks. If, in addition to this, we are dealing with a mixture instead of a single pure gas, the constituents will in general liquefy and re-evaporate with varying ease, tending to set up temperature differences between adjacent parts of the two legs of the U and thus requiring a further expenditure of work to operate the cycle.

Looked at from the point of view of gas separation, the first of these effects represents pure loss, but the second is due, at least in part, to overcoming what we have above termed the force of diffusion in separating the gases and should thus be counted as useful work.

The problem is, therefore, to provide just enough refrigeration *at the proper temperatures and places* to cover these two demands after they themselves are reduced to as low a value as possible in the design of the apparatus and by use of the best heat insulation attainable.

The three systems for gas separation now before us differ perhaps most strikingly of all in the way in which they produce this refrigeration.

In the case of the Linde, Fig. 2, the gas mixture to be

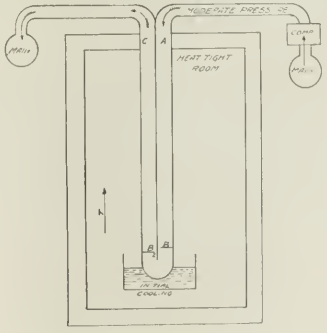


FIG. 1. IDEAL EQUAL PRESSURE

separated is pumped at very high pressure (say 1500 to 3000 lb. per sq.in.) into leg A and simply allowed to expand through a regulating throttle to a lower pressure at B_2 and return through D, the refrigeration being usually credited to the "Joule-Thompson effect." A discussion of this latter here would carry us too far into theoretical physics, but it may help the uninitiated in such matters to picture intelligently the general effect of this process to say that the specific heat of highly compressed gases is usually less than that of the same gas at lower pressure, so that a given weight of gas passing down leg A under high pressure in falling from one temperature to another will give up fewer calories

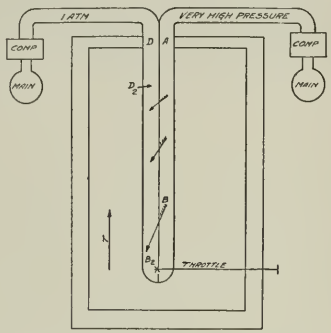


FIG. 2. LINDE SYSTEM, SELF-COOLING

of heat than the same weight of gas coming up the leg D will absorb between the same two temperatures. Thus it is evident that on the whole more heat will be carried out of the system by the issuing gas than is brought in by the incoming, with resulting refrigeration.

The fact that these differences of specific heat only become important at considerable pressures and the pressure created for this purpose is practically wasted at the throttle, as far as useful mechanical effect is concerned, makes this process decidedly inefficient from a thermodynamic standpoint; i. e., from the question of power consumption. Its chief merit lies in its extreme simplicity and freedom from moving parts. It is the type of system first developed both in the laboratory and commercially. As cooling proceeds, liquid finally forms at B_2. For the purpose of separating the constituents of the mixture the leg D is developed into a "column still" on the same principle as those used for rectification of ordinary liquids, but, to avoid confusion, not shown in the present cuts.

The Claude System

In the Claude system, schematically represented in Fig. 3, another principle is introduced. It was early pointed out by Lord Kelven and others that if some sort of expansion engine could be substituted for the free expansion throttle in systems of the Linde type and the work of these engines expended outside the heat-tight room, greater refrigerative effect would be produced even if all the mechanical work so produced were allowed to go to waste, for in its mere production it would have already extracted an equivalent amount of heat from this room. As, for the purposes in hand, these engines must work at very low temperatures, grave mechanical difficulties were seen in the problems of lubrication, brittleness of valves, stoppage by frozen impurities from the gas and the like. George Claude of Paris was the first to solve these difficulties, at least in a commercial way, and his book[5], recounting his experiences and discussing the general theory of the subject, is intensely interesting.

By use of an expansion engine, Claude was able to drop the initial gas pressure to from 400 to 600 lb. per sq.in., or even lower in some of the larger units recently erected for air separation. At these pressures the effect depended upon by the Linde system practically disappears so that, in practice, the Claude system works essentially on a wholly new principle rather than by the superposition of this upon that of the Linde process.

However, as Claude confined himself to one expansion engine[6], it was necessary for him, with his moderate initial pressure, to locate the engine's gas intake at a level in his interchanger sufficiently low so that the exhaust would reach the lowest temperature desired in the system and still be able to absorb quite an appreciable amount of heat at this temperature.

With the one engine taking its gas from the incoming side of the U, it is also evident that for efficient liquefaction only a part of the gas can be expanded through the engine, for, if liquefaction takes place in its cylinders, expansion to that extent is lost. The remainder of the gas must, therefore, be retained under pressure in the U and cooled down and liquefied by heat exchange with the expanded gas returning as indicated

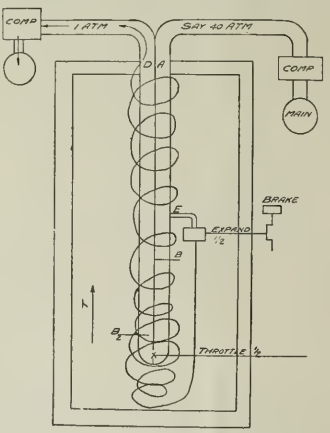


FIG. 3. CLAUDE SYSTEM, EXTERNAL WORK FOR COOLING

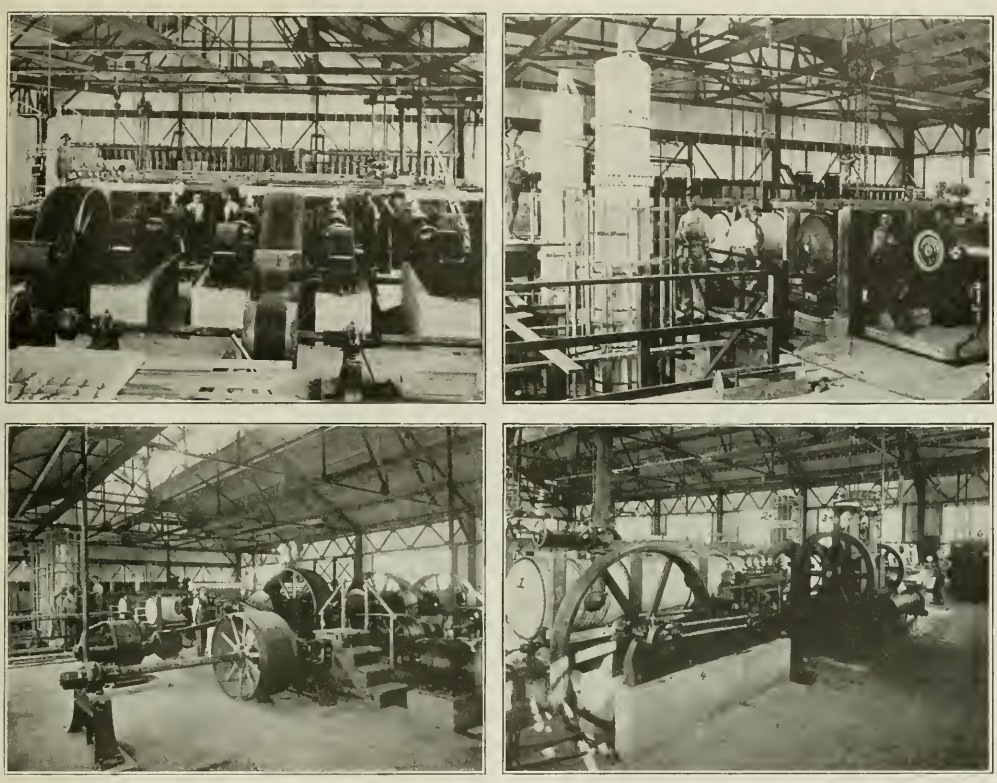
by the spiral line around both legs of the U. The gas after liquefaction in leg A is let into leg D through the throttle and there under the lower pressure rapidly drops still further in temperature by its own evaporation. Here it undergoes fractional distillation as already explained above.

The Jefferies-Norton System

Coming finally to the Jefferies-Norton system, Fig. 4, it will be noted that this differs from the Claude in

[5] "Liquid Air, Oxygen and Nitrogen," published by P. Blakiston & Co., Philadelphia.

[6] Though this is in many cases compound, having a high and a low pressure cylinder.



BUREAU OF MINES (JEFFERIES-NORTON) PLANT AT PETROLIA

Top left—Expansion engines. Top right and bottom left—General interior views. Bottom right—1. Interchanger. 2. Still. 3. Vacuum pump. 4. High pressure compressor for bottling finished gas. 5. Gage board. 6. Switchboard.

at least three important points, viz.: (1) The system employs more than one engine (in the illustration three, AE, BE and CE), each working through a different temperature range. The number of these temperature steps depends upon conditions, increasing with the total range of temperature to be covered and also with decreasing initial pressure employed. (2) The pressure in the outgoing leg of the U is only enough lower than in the incoming leg to allow for proper control of flow, unavoidable friction, head of liquid in the still trays and the like. (3) The engines work upon the gases after their liquefaction and distillation, thus permitting all the gas to be so treated. Incidentally, this also insures freedom from easily frozen impurities entering the engine valve chambers and cylinders and in many cases greatly simplifies the whole problem of initial purification of the gas to be treated. Engine C corresponds in a way to Claude's one engine system but as the initial pressure used in the system can, on account of its greater efficiency, be much less than in the Claude, the temperature range over which this engine works will be much less than in the latter. Since, when expanding a given weight of gas between two definite pressures, the work obtainable from it (and consequently the number of calories its expansion will extract from the system) is greater the higher its temperature, engine A will extract the most heat from the system and deliver the most power to the crankshaft per unit of gas used and engine C the least, which still further emphasizes the importance of this development.

Rough analogies, though suggestive, are often danger-

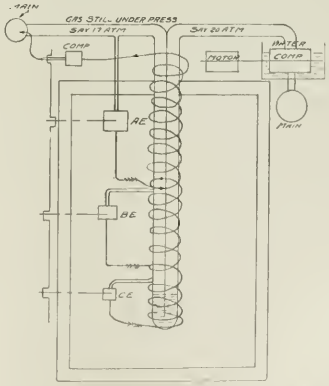


FIG. 4. JEFFERIES-NORTON SYSTEM, TEMPERATURE COMPOUNDED

ous to accuracy in scientific and technical explanations, but without laying any great stress upon it, the following may here be helpful to those not especially familiar with this subject. It was pointed out at the start that a considerable amount of the refrigerative effort which has to be expended in any of these processes is to remove the heat which, despite the best insulation we can put on the apparatus, still leaks in from without. Now in this sense the expansion engines of the last two processes may be thought of as engaged partly in pumping out this heat from the refrigerated system back to the outside, much as mine pumps are kept busy pumping out the water which leaks into a mine. Just as water may be coming in at various levels in the mine, so heat is leaking in to parts of the system at all levels of temperature. The one engine of the Claude system is analogous to the mine with a single pumping station at the very bottom where all water entering at any part of the mine is allowed to drain clear to the bottom and is then all pumped from there to the surface, while the Jefferies-Norton system is analogous to the installation of several pumping stations at different levels so that water from the upper levels is pumped out over the shorter lifts, thus saving power.

The really salient feature brought out in these diagrams is perhaps the progressive approach toward the ideal of thermodynamic reversibility and the high degree to which this is fulfilled in the basic principles of the last system.

* * *

PUBLISHED ARTICLES—F. G. COTTRELL

"Some of the Properties of Liquid Hydriodic Acid. (Co-author with R. S. Norris). *Amer. Chem. Jour.*, p. 96-105, February, 1896.

"On the Heat of Solution of Liquid Hydriodic Acid," *Jour. Phys. Chem.*, p. 492-495, November, 1898.

"Notes on the Action of Liquid Hydriodic Acid on Ethyl Ether." (Co-author with R. R. Rogers.) *Amer. Chem. Jour.*, p. 64-67, January, 1899.

"On the Solubility of Manganous Sulphate." *Jour. Phys. Chem.*, p. 637-656, November, 1900.

"Ueber ein saures Tripelsalz." Co-author with W. Meyerhoffer.) *Zeits. f. Anorg. Chem*, p. 442-444, July, 1901.

"Die Bildung von Langbeinit und deren untere Temperaturgrenze in den Salzlagern bei 37°." (Co-author with J. H. van't Hoff and W. Meyerhoffer.) Sitzber. d. R. Preus. Hrad. d. Wissensch. Berlin. Meeting of Mar. 13, 1902, p. 276-282.

"Der Restatrom bei galvanischer Polarissation betrachtet als ein Diffusionsproblem." Inaug. Dessertation Univ. Leipzig, 1903. Also published in *Zietschr. f. Physik. Chem.*, p. 385-431, January, 1903.

"Review of Physical Chemistry for the Year 1904." *Jour. Amer. Chem. Soc.*, p. 615-636, May, 1905.

"The Liquid Air Plant of the Chemistry Department, University of California." *Calif. Jour. Techn.*, p. 3-11, September, 1905.

"On Crystalline Habit." *Jour. Phys. Chem.*, p. 52-57, January, 1906.

"On Air Liquefiers." *Jour. Phys. Chem.*, p. 264-274, April, 1906.

"Recent Progress in Physical Chemistry." (Review for year 1907.) *Jour.* Amer. Chem. Soc., p. 288-302, February, 1908.

"Recent Progress in Physical Chemistry." (Review for year 1908.) *Jour.* Amer Chem. Soc., p. 394-403. March, 1909.

"The Electrical Precipitation of Suspended Particles." *Jour.* Ind. Eng. Chem., p. 542-550. August, 1911.

"Electrical Fume Precipitation." *Trans.* Amer. Inst. Min. Engrs., p. 512-520 and 755-763, N. Y. Meeting, February, 1912.

"Mineral Losses in Gases and Fumes." *Jour.* Ind. Eng. Chem., p. 182-185. March, 1912.

"An Electrically Heated Microscope Slide." *Jour.* Amer. Chem. Soc., p. 1328-1332. October, 1912.

"The Research Corporation, an Experiment in Public Administration of Patent Rights." Orig. Commun. 8th Intern. Cong. Appld. Chem., p. 59-69, October, 1912. Also *Jour.* Ind. Eng. Chem., p. 864-867, December, 1912.

"The Problem of Smelter Smoke." *Trans.* Commonwealth Club of Calif., p. 487-492, September, 1913.

"Some Reactions of Liquid Anhydrous Ammonia and Acetyline." *Jour. Phys. Chem.*, p. 85-100, February, 1914.

"Problems in Smoke, Fume and Dust Abatement." Ann. Rep. Smithsonian Inst. for 1913, p. 653-685, issued September, 1914.

"Recent Progress in Electrical Smoke Precipitation." *Eng. & Min. Jour.*, Vol. 101, p. 385-392, February 26, 1916.

"Government Owned Patents." Reprinted from Proceedings of the American Mining Congress, Chicago, Ill., November, 13-16, 1916.

UNITED STATES PATENTS—F. G. COTTRELL

Sept. 24, 1907. Manufacture of sulphuric acid.

Sept. 24, 1907. Apparatus for separating sulphuric acid.

Aug. 11, 1908. Art of separating suspended particles from gaseous bodies.

Jan. 11, 1910. Effecting interchange of electric charges between solid conductors and gases.

April 29, 1913. Filtering medium and process for making the same.

Feb. 6, 1912. Purification of gases.

March 21, 1911. Separating and collecting particles of one liquid suspended in another liquid.

March 21, 1911. Apparatus for separating and collecting particles of one liquid suspended in another liquid.

June 15, 1915. Synchronous electrical contact-maker.

Aug. 13, 1912. Apparatus for separating suspended particles from gaseous bodies.

March 21, 1911. Process for separating and collecting particles of one liquid suspended in another liquid.

March 21, 1911. Separating and collecting particles of one liquid suspended in another liquid.

July 22, 1913. Method of discharge of electricity into gases.

Engineering Council Establishes National Service Committee

IN ORDER more completely to provide for united action upon matters of common concern to engineers, the Engineering Council has recently organized a National Service Committee and has established an office in the national capital at 502 McLachlen Building, 10th and G Streets, the office of M. O. Leighton, chairman.

The Engineering Council, through this National Service Committee and its Washington office, intends to accomplish the following general purposes, this committee acting always under the direction of the council and within limitations fixed for it:

1. To discover public services which may best be performed by engineering societies, and, when desired, to offer the proper men for such services.

2. To speak authoritatively for the Engineering Council before committees of Congress and departments of the Government on all public questions of common interest to engineers, within such limitations as the council may set from time to time.

3. To give promptly wide circulation among engineers to authentic information regarding pending legislation and executive actions which may affect the interests of engineers in any way.

4. To gather opinions of engineers on these matters.

The Engineering Council's aim is disinterested usefulness to the nation and the profession—not advocacy of any selfish ends—by giving unbiased information and counsel on technical matters, chiefly when asked. A modest start is being made. The work will be enlarged only as a real demand for services develops.

Meeting of American Institute of Chemical Engineers

Review of Proceedings of the Annual Meeting, Officers Elected—Advocate Adequate Tariff Protection, Anti-Dumping Law, Proper Means for Disposition of Government Stocks of Chemicals—Plants Visited—Our Chemical Industries Made Permanent, Webb Law, Open Price Associations

SUBSCRIPTION DINNER AT CONGRESS HOTEL

THE Chicago meeting of the American Institute of Chemical Engineers, Jan. 15-18, was in a number of respects the most successful ever held by this society. The keynote of the entire meeting was well expressed in the title of the symposium held on the opening day—"The Maintenance and Preservation of Our Chemical Industries." This is the most timely and vital subject at the present time which could be chosen for a meeting of chemical engineers.

The large attendance at the meeting indicated that the importance of the topic was realized by the members of the Institute as well as by the Chicago chemists and the chemical industries that sent representatives to the meeting. The United States Government was represented by Dr. Grinnell Jones, the chemist of the U. S. Tariff Commission. The attendance at the opening session of the meeting on Wednesday morning was about 100 and reached a maximum of about 250 on Thursday evening, when Col. Alfred H. White spoke on "The Present Status of Nitrogen Fixation" and Prof. Julius Stieglitz made an address on "The Manufacture of Synthetic Medicinal Compounds." The weather throughout the meeting was fair and mild. The increasing public interest in the chemical industries was shown by the amount of space given by the Chicago papers to the meeting and the presence throughout the entire meeting of a special representative of the *Literary Digest.*

The meeting was opened on Wednesday morning by President Thompson. The address of welcome was given by Mr. Leonard Busby, president of the Chicago Surface Lines. In welcoming the chemical engineers, Mr. Busby expressed as a business man his realization of the important part which the chemical engineer had played in winning the war and developing the resources of the country and the important problems still awaiting solution.

Officers Elected

During the business session the report of the canvassing committee showed that the following officers had been elected for the coming year: President, Arthur D. Little; vice-president, Prof. Albert W. Smith; secretary, Prof. John C. Olsen; treasurer, Dr. F. W. Frerichs; auditor, Dr. Charles F. McKenna; directors for three years, J. V. N. Dorr, Herbert Dow and Hugh K. Moore.

The secretary reported a membership of 306, which is an increase of 22 during the past year. Eight applications for membership had not yet been acted upon. The membership committee reported action on 19 applications since the last meeting. Several applicants had been rejected on account of insufficient chemical engineering experience or non-conformity with the code of ethics of the institute. The treasurer reported a substantial balance and $1250 invested in Liberty Bonds.

Prof. James R. Withrow, chairman of the committee on chemical engineering education, reported arrangements for having a copy of Dr. Mann's report on engineering education sent to all members requesting it. Prof. Withrow's committee will present a full report on this very important study of engineering education at the next meeting of the institute, when opportunity will be given to discuss the report.

The committee on meetings reported invitations from Boston, Atlanta, Providence and Cincinnati for the summer meeting with the recommendation that Providence be selected for the summer meeting and that a winter meeting be arranged for Atlanta, and that arrangements be made to visit the important industrial centers in that vicinity. The entire matter was left to the council with power.

After the business session the remainder of the morning, as well as the afternoon and the evening, was devoted to papers and discussion of the important topic, "Maintenance and Preservation of Our Chemical Industries."

The address of President Thompson was devoted to this topic under the title "Chemical Industries Made Permanent, and is given in full elsewhere in this journal.

Resume of Conditions

The next speaker was Maximilian Toch, who, with L. H. Baekeland as a special committee, had arranged the symposium and invited chemical manufacturers to send representatives to the meeting. Mr. Toch presented a résumé of conditions as they exist to-day in the chemical industries. He stated that more than 2,000,000 men and women are employed in the newer chemical industries. The need for tariff protection for these industries is shown by the fact that before the war the dye azo scarlet was imported and sold for between 15 and 20 cents per pound. To manufacture this dye in the United States to-day costs 85 cents per pound, which may possibly be reduced to 65 cents if the cost of raw material and labor is reduced.

Mr. Louis Matos, representing the National Aniline & Chemical Co., emphasized the great cost of developing the method of manufacture of coal-tar dyes and stated that it would be from three to five years before reliable data on production costs could be obtained.

Mr. Robert Hilton stated that the Ault & Wiborg Co. had invested a large amount of capital in the manufacture of dyes and that it would be absolutely impossible to meet the competition of the well-established German industries unless a much higher protective tariff were enacted by Congress.

Mr. William H. Rollin of the Rollin Chemical Co. discussed "The Future of the Barium Industry" and stated that this industry is still in its infancy and has not had time to become well established or financially strong. Freight rates will also be a determining factor in the future of this industry. While railroad rates are high, ocean freight rates from Europe may become so low that importation will be stimulated. Mr. Rollin stated that the survival of the barium industry was almost entirely dependent upon a protective tariff.

Mr. Colby Dill of the Perth Amboy Chemical Works maintained that the solution of the problem could be found in more and better research work being carried out on our chemical processes, employing for this work the chemists who have been released by the Government. Mr. Dill maintained that with good team work the American chemical engineer could meet foreign competition, as he has shown himself to be more resourceful and progressive than his foreign rival.

Advocate Anti-Dumping Law

During the general discussion of these papers a drastic anti-dumping law was advocated. The licensing system adopted by Great Britain was also urged as a very effective remedy. Under this system the importation of dyes and other chemicals is prohibited when domestic manufacturers can supply the market and importation is permitted only to the extent required to supply the domestic market with chemicals not manufactured in the country or of which the production is not sufficient.

Dr. Grinnell Jones, chemist of the U. S. Tariff Commission, read a paper on "Recommendations of the Tariff Commission in Regard to Dyes and Coal-Tar Chemicals." Dr. Jones discussed the provisions of a bill proposed by the commission to Congress making 45 amendments to the bill of Sept. 8, 1916, which established a tariff which encouraged the investment of capital in an American dye industry. The proposed amendments make no radical changes in the present tariff law either as to rates or classification, but merely correct some technical errors in the present law by which the evident intent of Congress is nullified. The tariff rates would therefore remain as at present, namely, 30 per cent plus 5 cents per pound on the finished dye, 15 per cent and 2½ cents per pound on intermediates, while the crudes are on the free list.

The Tariff Commission has no power to recommend rates of duty or to determine general policy as to high or low protection or free trade. These questions must be settled by the people. For this reason no material increase in tariff is likely until after the next Presidential election. The remedy therefore for the present predicament of the chemical industries is to be found in the reduction of manufacturing costs by the work of the chemical engineer and a change in the general economic condition.

Broad Reconstruction Program

Dr. Edward Gudeman in a paper on "Reconstruction Aspects of Some Chemical Industries of the United States" urged the adoption of a very broad reconstruction program. He advocated not only protection for our newly established chemical industries, but also conservation of our national resources, both material and human, by improving living conditions, giving employment to discharged soldiers and sailors, universal education in English, economic equality and development of our transportation facilities.

At the conclusion of the discussion a set of resolutions was adopted which had been drafted by a committee consisting of President Thompson, Secretary Olsen, F. E. Dodge, F. M. Dorsey, Edward Gudeman, A. H. Hooker, H. W. Kellogg, C. Bai Lihme, Louis Matos, S. W. Parr and Maximilian Toch. The resolutions strongly urged Congress to provide adequate tariff protection, enact an anti-dumping law and also so to dispose of Government stocks of chemicals that the market may not be demoralized.

A complimentary luncheon was served on Wednesday by the local committee to members of the institute and their guests. The local committee had also arranged for a smoker on Wednesday which was well attended and very much enjoyed by all.

Corn Products Co. Plant Visited

Thursday was spent in a visit to the large plant of the Corn Products Refining Co. at Argo, Ill. Two special cars had been provided by the local committee for transportation to the plant. The party of 54 was divided into small groups for the inspection. The following members of the company acted as guides: F. M. Sayre, superintendent; C. L. Soverign, superintendent of the refinery; Harry Reynolds, foreman of the starch department; Otto Sjostrom, research chemist, and Al Peterson. The plant is the largest of its kind in the world, the daily grinding of corn being 60,000 bushels, and $1,000,000 is being spent in improvements and additions to the plant on account of the increasing consumption of corn products.

The process of separating the constituents of the kernel of corn into starch, gluten, germ and hull was first shown. The starch house was then inspected. Here the raw starch is refined and dried. The sugar refinery was then visited where the starch in 10,000 lb. batches is converted by heating under pressure in the presence of muriatic acid into dextrine or dextrose. Part of the production of this department is glucose or karo and part is 80 per cent sugar, 250,000 lb. of sugar being produced daily.

The oil house was also visited, where corn oil is expressed from the dried germs by means of Anderson expellers. The oil is refined and sold as mazola. In the feed house all by-products of the plant are converted into cattle food. The power house was also visited and its excellent condition admired by the visitors. Automatic devices for operation, control and recording of performance had been installed wherever feasible. Electric power distribution was used throughout the plant.

Luncheon was served to the party in the commodious, well-lighted and well-kept employees' restaurant. The luncheon was identical with that served to the employees for 29 cents, which is the cost exclusive of rent and maintenance of the building. The luncheon was first-class in quality and quantity.

Welfare Work Explained

After luncheon Mr. F. M. Sayre, the superintendent of the plant, explained the welfare work being carried on by the company and the plan recently introduced for bringing about satisfactory relations with the employees. This plan included the election of an advisory committee of three employees in each department. All questions relating to working conditions in the department were brought before this committee sitting with the superintendent of the department. Appeal could be taken to a general committee elected by all employees of the plant, which met with the general superintendent. This plan had worked out very satisfactorily and the excellent relations existing between employees and the superintendent were very evident during the inspection of the plant. There are employed in the plant 1900 men and 600 women.

On Thursday evening Col. Alfred H. White gave a description of the nitrogen fixation plants which had been projected or erected by the Government. Lantern slides of some of these were shown. The plan decided upon contemplates the utilization of several of the nitrogen fixation processes which had proved commercially successful.

At plant No. 1, located at Sheffield, Alabama, synthetic ammonia was produced from nitrogen and hydrogen by a modification of the Haber process. The contemplated capacity of this plant was 60,000 lb. of ammonia daily, half of which it was planned to oxidize to nitric acid in order to produce ammonium nitrate. One unit only of this plant has been operated. The second plant, located at Muscle Shoals, utilized the cyanamide process and was designed to produce 110,000 tons of ammonium nitrate. This plant will be closed Feb. 1 until Congress shall determine what disposition shall be made of it. Plants 3 and 4 were located at Toledo and Ancor, Ohio, and were cyanamide plants. A 10-ton experimental plant had also been erected at Saltville, Va., to try out the Bucher process of producing sodium cyanide.

Prof. Julius Stieglitz then addressed the institute on the subject, "The Production of Synthetic Medicinal Compounds," Prof. Stieglitz explained how progress had been made in the study of the effect of specific organic groups or radicals on the human system and urged that more attention be given by chemists to this important field of research. He mentioned the production of synthetic adrenalin, which can be injected directly into the blood and which in 25 minutes will give effective relief to asthma patients.

Other Papers Read

At the Friday morning session the following papers were read and discussed: "Reinforced Concrete Tanks for Storing Ammonia Liquors," by F. W. Frerichs; "Concrete as a Chemical Engineering Material," by Maximilian Toch. In both of these papers methods of rendering concrete proof against erosion, chemical action, disintegration and decomposition were given. A paper on "Some Wild Engineering I Have Known" was read by David Wesson. A paper on "Chemical War Secrets and Manufacturers' Rights," by Edward Gudeman, emphasized the care which must be taken by Government officials not to divulge manufacturing secrets given them for war purposes.

"Belting for Power Transmission," by Ernest D. Wilson, brought out a very interesting discussion on this subject. Mr. Wilson presented the results of experiments showing that in most instances leather belting is the most efficient for power transmission.

After partaking of another complimentary luncheon furnished by the local committee, members and their guests proceeded by auto to the plant of the Lindsay Light Co., where the entire process of manufacture of incandescent mantles was shown. A new method had been worked out for the manufacture of thorium and cerium nitrates from monozite sand. The preparation of the fabric mantle, as well as the impregnation and burning off of same, was shown in detail.

The Underwriters' Laboratories of Chicago were then visited. The great variety of tests, both physical and chemical, which are carried out in this laboratory was

surprising. A great deal of interest was shown in the fire tests which were made on complete building walls cosntructed of various fire resisting materials.

The subscription dinner was held on Friday evening at Congress Hotel. About 60 covers were laid. The first number of the after dinner program consisted of several vocal selections by Mme. Myrna Sharlow of the Chicago Grand Opera Company.

Mr. Arthur Lowenstein introduced the well known poet and humorist, Mr. Wilbur D. Nesbit, as the toastmaster of the evening. The audience was kept in a roar by Mr. Nesbit's sparkling wit and humor. He first introduced Dr. L. V. Redman, chairman of the Chicago Section of the American Chemical Society, who spoke on "Why Is a Chemical Engineer?" "The Problems of the Chemist as Seen by a Layman" was responded to by Vincent Rockey of the research department of the *Literary Digest*. Mr. Rockey spoke of the great change which has come in American public opinion from indifference to intense interest in chemical topics. Dr. Grinnell Jones spoke of the work of the Tariff Commission. President Thompson was given the topic, "Chemical Horse Sense," and ingeniously drew many parallels and contrasts between the chemist and the most intelligent and faithful of domestic animals.

Secretary Olsen was called upon for a toast to "The Future of the Institute." While denying any ability as a prophet, Dr. Olsen asserted that if the institute did its work with the same energy and success displayed by the local committee in preparing for the Chicago meeting its future would be very bright. Speaking on the subject "Some Chemical Fakes I Have Met," David Wesson told of a number of very amusing incidents he had experienced.

On Saturday morning a number of the members visited the plant of the Standard Oil Co. at Whiting, Ind. This plant has been practically rebuilt during the last three years.

The number of ladies present at the meeting was not as large as at previous meetings, but those who were present were royally entertained. The program included a theater party on Thursday evening and grand opera at the Auditorium on Wednesday evening, as well as an auto trip through Chicago's park system. The ladies were also present at the luncheons on Wednesday and Friday and also at the subscription dinner on Friday evening. The members of the local section of the American Chemical Society participated in all sessions and functions of the meeting and materially assisted in making the meeting a success.

The committees were as follows:

General chairman, F. M. de Beers.

Finance Committee—A. W. Ayers, chairman; C. F. Hagedorn, G. N. Prentiss.

Entertainment and Reception Committee—F. W. Willard, chairman; C. B. Lihme, Edward Gudeman, Arthur Lowenstein.

Excursion and Transportation Committee—Harry McCormack, chairman; William D. Richardson.

Papers and Meetings Committee—L. W. Andrews, chairman; G. H. Pickard.

Publicity Committee—William Hoskins, chairman; P. B. Sadtler.

Ladies' Committee—Mrs. W. D. Richardson, chairman; Mrs. G. W. Willard, Mrs. Millner.

Our Chemical Industries Made Permanent

By G. W. Thompson*

DURING the last four years our chemical industries have had a wonderful opportunity to lay the foundation for a permanent development. This opportunity was occasioned through the cutting off of foreign competition and also through the abnormal demand created by war conditions. This period has passed and we are now on the threshold of another era, an era of readjustment, an era calling for the greatest intelligence and activity of mind if what already has been accomplished is to develop into a permanent industrial gain. To solve the problem of making our chemical industries permanent, it is necessary to study carefully the conditions that are confronting us so that means will be devised for properly meeting them.

There are certain things that can be eliminated from consideration at once. The production of chemical products having practically only war uses must cease. It is to be presumed that no one would advocate the continuation of wars in order that these products should continue to be produced. The proper study should, of course, be made to find out how the chemical products needed for war purposes can be used for peace purposes. It seems improbable, however, that much can be done in this direction. Of course much of the apparatus used in the production of munitions of war can be used in the production of those things needed in peace, and to that extent such industries can be modified and put, as it were, upon a peace basis. It is presumed, also, that in those industries established or developed for purely war purposes, a conservative policy has been followed so that the plants have been more or less paid for from war profits. If this conservative policy has not been followed, I know of no means of preventing financial loss. Such industries should take their losses and start in again on a new basis, manufacturing, if possible, peace products.

Let us consider now the problems that confront the manufacturer of chemical products for which there is a peace demand. We will attempt to list these problems and then proceed to analyze them more fully. As we see it, these problems are: first, how to meet foreign competition; second, how to correct destructive domestic competition; third, how to meet the losses which may result from falling prices, should falling prices come as is expected by many; fourth, how to meet the problem of high wages, with the probability of their also falling; fifth, how shall our chemical industries more intimately organize for peace production.

Foreign Competition

Judging by the expressions of opinion which have so far appeared in the chemical journals, foreign competition presents the most serious problem. The greatest difficulty, however, that arises in considering this problem lies in what we may expect under this heading. There are many diverse views. Some seem to think that Germany will, as soon as possible after peace is declared and the avenues of trade are opened up, commence to dump manufactured chemicals upon the markets of the world. German competition in the past has been considered unfair competition, and it is claimed, with-

*Address delivered at the Chicago meeting of the American Institute of Chemical Engineers, Jan. 15, 1919.

out contradiction and perhaps, on the other hand, without sufficient confirmation, that she followed the deliberate practice of selling goods under cost in certain markets until the local concerns supplying those markets were compelled to give up business, and when this result was obtained the price of the German product would be raised higher than the domestic product had been sold for. The Germans would continue to hold the market, as domestic manufacturers would not dare to recommence manufacture with the menace of the unfair German practice still existing as a possibility. The danger of Germany resuming practices of this kind is considered very real by many chemical manufacturers. How real this danger is we have no means of definitely determining.

Before the war international trade was essentially anarchistic; that is to say, each nation controlled, as it thought best, all questions relating to export and import; everything was permissible under international law. Import taxes could be raised or lowered by any nation as it saw fit. Each nation could lay down its own rules for import admissions. The nearest thing to a general rule which would remove international trade from the anarchistic class was such provisions in treaties in what are known as the most favored nation clauses. These clauses prevented any nation from discriminating against another nation protected by such a treaty in the matter of import or export restrictions.

Germany's Abuse of Freedom of Trade

Under these conditions, as has been stated, everything was permissible, and Germany was best known among the nations of the world for its aggressive abuse of this freedom in international trade. It has been claimed even, that if a manufacturer in another country attempted to follow the same practices as Germany followed, and shipped goods to Germany for the purpose of selling them in the German market at the market price or perhaps below it, he ran the danger that some quickly executed decree would prevent the entry of his goods into Germany, perhaps just at the moment when they had arrived at the German port of entry. An attempt by an individual manufacturer to break down this vicious German practice would, if successful, inure not to his benefit only, but would inure to the benefit of the other manufacturers in his own country and throughout the world. Partly to meet this situation, what was known as the Webb law was passed by our Congress, which permits manufacturers to combine for export business. This law was passed, however, too late to be of much use to American chemical manufacturers, as the war had started. As we are considering the problems now, and not presenting the solution, we will consider the Webb law further on when we are talking of this solution.

The danger of Germany becoming an acute and disturbing factor in international trade is increased by the prospect that Germany will be compelled to incur heavy bonded indebtedness held by foreign nations and their peoples. If Germany should largely become a debtor nation, she can only pay the interest on her debts by an excess of exports over her imports. The heavier the burden laid upon Germany in this respect, the more certain Germany is to become a competitor in the world's markets. Her gold will be drained from her and as soon as that draining has reached its practical limit, the only thing that she can then pay with will be the products of her labor. As she will need all she can earn to pay her taxes and indemnities and as these will increase her production costs, she may not be able to sell at prices that are menacingly low.

A Future Economic Problem

Couple with this the fact that during the war the United States has become a creditor nation and its credits and the interest upon them can only be paid, to a certain extent, in gold, of which apparently we have more than is good for us at the present time, and the remainder in merchandise, it can readily be seen that we are in danger of having goods offered to us at relatively low figures, not only by Germany but all other countries, these goods consisting at least to some extent of chemical products.

In order to give a true picture, however, of the situation, we must not neglect to look at the other side. German chemical industries, except for war purposes, have been almost at a standstill for over four years. Many of her plants must have passed into a condition of innocuous desuetude. Each of us knows what it means for a plant to be practically idle for four years. The plant itself deteriorates and the men on whom the successful operation of the plant has depended have become scattered, in many cases have died, and in all other cases, to a certain extent, have lost their art. It is hardly probable that the German chemical industries (speaking now with reference to peace products) are in anything like the good shape in which they were before the war. Furthermore, it seems probable that chemical research along peace lines must have almost ceased in Germany. In this country the reverse of all of this is the case. Our chemical industries have received a tremendous impetus. Men have become trained in chemical operations. Extensive chemical research has been going on in connection with peace manufacture.

Germany an Ishmaelite

There is another phase of this situation, too, that must be considered. Germany has become the Ishmaelite or the pariah of nations. Practically the whole world is wrought up with an intensity of feeling that will prevent the sale of her products if known to be of German origin. Think of this picture as portrayed by James Church Alvord in the New York *Times*:

> By rotting wharves her empty ships shall rock,
> Her shattern towns their poverty proclaim,
> Her high-towered factories topple block by block
> "Since "Made in Germany" is a brand of shame.
> Thrust from the door of Human Brotherhood,
> Misunderstanding and misunderstood,
> Beggared, unpardoned, excommunicate—
> The Ishmaelite shall wait.

If the picture is a true one, can we really have very much to fear from serious competition with Germany? If true, it indicates that Germany has beggared herself morally and physically, that about the only thing a German can do is to leave his native country, change his name and try to rehabilitate himself in other climes. Mind you, this picture is not one that I am painting, and I do not present it as a picture originating in my mind, but I do present it as a picture that is in the minds of a very large percentage of civilized peoples.

Assuming the very worst as to the dangers of German competition, what is the best method of procedure, utilizing implements at hand, for meeting such competition? I offer three practical solutions. The first of these is a combination of the chemical industries for export trade purposes, under the so-called Webb law; second, the formation, in the chemical industries, of what are known as Open Price Associations; and, third, the combination of chemical concerns which are not competitive and which are too weak to stand alone—by combining they would be strong.

Webb Law

This law, which went into effect April 10, 1918, has for its purpose the granting of permission to domestic manufacturers, sales agents, etc., to combine for the purpose of fixing prices and controlling export trade in the industries in which they are interested. The act starts off to define what is meant by export trade, which means solely trade or commerce in goods, wares or merchandise exported or in the course of being exported from the United States or any territory thereof to a foreign nation. The act is presumed to relate to trade outside of the United States or any of its possessions, such as Porto Rico, the Philippines, etc. In the act the word "association" is used, which is declared to mean "any corporation or combination, by contract or otherwise, of two or more persons, partnerships, or corporations." Evidently it permits a pooling of export profits, which is not permissible in domestic trade to the extent that it interferes with competition. To accomplish its purpose, the act simply declares that previous acts, including the so-called Sherman law, shall not be construed to apply to associations entered into for the sole purpose of engaging in export trade and actually engaged solely in such trade, provided such association does not "enter into any agreement, understanding, or conspiracy, or do any act which artificially or intentionally affects prices, in the United States, of the commodities of the class exported by the association, or which substantially, in the United States, or otherwise restrains trade therein." It also provides that the act creating a federal trade commission which defines and prohibits unfair methods of competition shall not be construed as to apply to competition in the export trade. It also calls for the filing with the Federal Trade Commission full details as to the association formed under the act, and penalties for failure to make proper reports. It also gives to the Federal Trade Commission power to initiate prosecution of associations that do not operate within the limitations of the act.

Aim of the Act

This act apparently will permit manufacturers, etc., to form associations that can do practically anything in export trade, so long as their acts do not restrain domestic trade or affect competition therein. It would appear that these associations could do things in export trade that would be considered unfair in domestic trade. Thus if any foreign country attempts to dump its goods on this country for the purpose of injuring domestic trade, the export association could retaliate by selling abroad its products, even at a loss, in order to prevent such dumping.

It is possible, however, that this phase of the act may be subject to the qualifications that the association's export sales are distinctly for the purpose of building up foreign trade and not for the purpose of interfering with domestic competition. However, an act of this kind will have to be interpreted as its practical applications develop. One thing is clear, however, that if associations are formed under this act before foreign goods can be dumped upon this market, and if these associations aggressively seek to develop our export trade in products which might be dumped upon our market, no criticism could be made, as it could not be shown that they had directly affected competition in this country or restrained domestic trade.

I do not know that I have made my point clear. Let me illustrate it. Suppose there is a certain product which our domestic manufacturers fear may be dumped upon our market. Manufacturers who are engaged in the production of this product can form an export association. If this association is formed in time and endeavors to develop foreign trade in this product before the same product made abroad can be imported, their act cannot be considered in any way illegal. It would also appear that they can continue to offer this product abroad on the same basis of price, etc., even after the foreign-made product was offered in this country. If, however, the association was not formed or did not commence to act until the foreign product had already been dumped upon this market, thereby depressing domestic prices, and they should then go into the foreign market for the purpose of preventing such importation, with the result that domestic prices would be increased, the association might be doing an illegal act. I am only attempting to give a common-sense view of this phase of the subject and it may be that my opinion is subject to revision by the mind legally trained. Also it would be manifestly foolish for me to give advice as to what should be attempted under this law in any particular case. Each case should be judged of by itself.

Pooling of Selling Interests

The main purpose of the act is undoubtedly to provide for collective bargaining in the export business. By collective bargaining is meant the pooling of selling interests so that those in the pool will not be bidding against each other, thereby depressing prices.

It is interesting to note that a number of associations have already been formed under the Webb law. Very few associations have so far been formed covering the chemical industries. It is presumed, also, that most of the associations so far formed have been for the purpose of providing collective selling, as in the case of the recent associations covering copper and steel, formed under the names of the Copper Export Association and the North American Steel Products Corporation. No one can tell to what extent the utilization of the Webb law will assist chemical industries. It certainly should, however, be studied by our chemical industries, both from the business and legal standpoint, so as to see how profitable use can be made of it. It would appear to be a very efficient instrument for the development of export trade and the meeting of foreign competition.

During the last few years a great many Open Price

Associations have been organized. Some few of them have been formed covering certain branches of chemical manufacture. Open Price Associations have for their purpose the bringing together of manufacturers of competing products, for the purpose of establishing trade practices and for the general welfare of the trade, to encourage a spirit of good will and mutual confidence among their members and with the trade, to co-operate with each other and with the Government authorities, to prevent unfair methods of competition and trade abuses, to study and adopt ways and means of eliminating waste in production and distribution, to establish and maintain standards as to quality and to induce truthful branding of products, to study manufacturing costs, devise scientific methods of accounting, and to furnish the members with useful information. All of these things an Open Price Association can do if it determinedly avoids anything like a reduction in competition or attempts to control prices. Apparently Open Price Associations have met with the approval of the Federal Trade Commission. One of the great evils they seek to correct is what may be described as the sporadic cutting of prices, due to misinformation as to what competitors' prices are. Thus, John Jones hears through the trade that James Smith is after a certain line of business and has quoted very low figures. In a great many cases the information which has come to John Jones is false and is not, under ordinary conditions, subject to verification. He simply has to guess as to what James Smith is doing, and, being fearful that James Smith may beat in the race, he becomes nervous and cuts his price to a figure in which there may be no profit or even a loss. Such a condition is ruinous to business; it serves no good purpose and is in the nature of unfair competition. If, however, there were some system provided whereby John Jones would know in due time exactly what James Smith was quoting, or vice versa, neither of them would be willing to go on record in making ridiculous quotations.

Two Methods of Procedure

This indicates the essential feature of Open Price Associations. To accomplish its purpose two general methods of procedure may be followed. One method is that each member of the association reports to its secretary all sales, the secretary in turn reporting these sales to all of the other members of the association. The other method of procedure is this: If all members published their price lists, they would then report to the secretary only deviations from the price list, the secretary then advising all the members of such deviations. The second method is one most easily followed with staple products.

Of course it is obvious that no Open Price Association of the kind described can exist unless the members of the association have a certain degree of confidence in each other. The simple reporting of prices or deviations from price lists will not accomplish much unless the members are honest in their reports. In other words, it is the spirit which develops out of such an organization that is its real value, the spirit of confidence. I presume that in the formation of these organizations, in some cases, the members have come together with the fear and trepidation which Ali Baba felt when he entered the cave of the forty thieves. After an organization of this kind has been in existence for a while, however, each one begins to be ashamed of himself for having thought so poorly of his competitors and he finds that after all he has no monopoly on honesty and that the other members of the association are not very much better or very much worse than he is. As time goes on he also finds that they are a great deal better than he ever thought it possible for them to be.

Right Spirit Must Prevail

The Open Price Association is not a cure-all, and unless entered into with the right spirit it undoubtedly could become a menace. The great temptation for the members of an association is to think that they are gathered together for the purpose of controlling or regulating prices, which of course is illegal. Those that appreciate this danger will studiously avoid any attempt at the control of prices. The association should not eliminate competition; it should not attempt to say what any member shall do with respect to prices. So far as I know, no Open Price Association has as yet been accused of attempting to regulate prices. Some time such an accusation may be made, but if so, every other association will, for its own safety, more strenuously stay safely within the legal line.

I urge upon the chemical industries the study of this proposition. I believe wherever an Open Price Association is established among chemical manufacturers the result will be better trade conditions, more uniform and more legitimate profits and a greater respect on the part of the consuming public. The cutting of prices below what will give a legitimate profit is not good for the consumer because in the long run what the consumer needs is stability in prices that are sufficiently low. He should not want an unfair advantage in the purchasing of goods, nor should he want a manufacturer to supply him with goods on which a reasonable profit has not been made.

Some Open Price Associations have considered the possibility of using their associations in the furtherance of export business. This is a legitimate development of the Open Price Association, although better conducted in associations formed under the Webb law. Whatever they may do in this respect, however, it is certain that in Open Price Associations there is an opportunity presented for the discussion of foreign competition. They can act collectively within certain broad limits to cope with this competition. They can conduct an advertising campaign in favor of domestic products. They can furnish each other with information which will enable them to manufacture more cheaply and so be able more easily to meet foreign competition.

The chemical concern that manufactures only one product, or only a few products, is at a great disadvantage as compared to a concern that manufactures a great many products. The uses of chemical products come and go, the demand for them rises and falls, new chemical products are discovered which are continually displacing those previously manufactured. The profits of a concern manufacturing one product, on being plotted, will show as a rule a very irregular curve. There may be frequent rises and falls; there may be a very rapid rise and then a very rapid fall. I think

if any large chemical manufacturing company had the information at hand and could plot its profits with regard to individual products, it would be found that these curves would be very irregular and, on the other hand, that if they were all combined, other things being equal, there would be shown a more nearly continuous and uniform curve that, with a well-managed concern, would steadily rise.

Widen the Base of Business

I am therefore laying down the rather fundamental proposition that concerns manufacturing chemicals should have as wide a base as possible in order to maintain their stability. I am probably offering nothing new in this suggestion; most chemical companies see the point involved and they have diversified their industries so that loss in one department will be corrected by profits in others. I am wondering if it is not true, however, that during our war period many concerns have gone into the manufacture of specialties without a broad enough base to give them permanence. Is not it possible that there are chemical manufacturing companies in this country that are on too small a base, but which, if combined with some other industry in a similar condition but manufacturing different products, would be able to weather the storm of competition? I am wondering if we have sufficiently learned our lesson from Germany in the diversification of our chemical industries. Are our manufacturing chemical concerns each as inclusive as the German companies in the number of products that they manufacture? Here is a path of progress that I am sure leads to profit.

Combines Suggested

It would be foolish, however, for a concern that is manufacturing one or a few products, to think that the only way for him to diversify his industry would be by increasing the number of products. Probably the best thing for it to do would be to combine with some other concern similarly situated but manufacturing other products. As I see it, there is nothing illegal in such a combination, as they were not competing. Of course, to a certain extent, even competing industries can combine, so long as the combination is clearly not one in restraint of trade, and the mere fact that some of the products of one of these companies are manufactured by the other company is no reason in itself why the two companies should not combine, unless by so doing they obtain a monopoly of product. I am not advocating such a combination. The combination I do advocate is only one which will result in the broadening of the base and the diversification of the industry. In many cases the by-products of one of the companies could be utilized in the manufacturing of the products of the other company, the economy thus resulting being a benefit to both and to the public at large.

If a chemical concern cannot hold its own in domestic competition, how can it hope to meet foreign competition as well? If it rests on a narrow base, how much more likely it will be to topple over in the struggle of foreign competition. By broadening its base it can withstand competition both domestic and foreign.

The danger of our chemical industries being injuriously affected by foreign competition would be very much lessened and in some cases would be entirely removed if our chemical industries made use of the three instruments I have outlined, to wit: Association for export business, under the Webb law; second, the formation of Open Price Associations; and, third, the diversification of industrial operations by such combinations as are possible without destroying competition. Individual initiative would remain intact in the case of all of these instruments and would not involve the asking for Government assistance.

Destructive Domestic Competition

Asserting that the elimination of domestic competition, so far as it is destructive to industry, can only be brought about by combinations which to a greater or less degree restrain trade, there are those who advocate the repeal of the Sherman law so as to permit combinations in restraint of trade. Personally I am opposed to any advocacy of the repeal of the Sherman law, primarily because I do not believe that it is a menace or that its repeal is necessary. Particularly is this true with regard to our chemical industries. I have already indicated how, to a certain extent at least, the evils of old-fashioned competition can be eliminated by Open Price Associations, and I have also indicated that the real need of our chemical industries is diversification through combinations that are not in restraint of trade. My principal objection to doing away with the Sherman law, outside of the fact that you could not get it repealed if you wanted to, lies in the proposition that nearly all progress is traceable to competition. If you destroy competition, you destroy individual initiative, which is the thing that above all other things should be developed. Forms of organization which appear to be logically complete but which after all substitute autocratic and bureaucratic methods for individual activity have in them the seeds of their own destruction.

To meet destructive domestic competition, all I have to suggest is the formation of Open Price Associations and the diversification of industries through combinations that are not in restraint of trade.

Falling Prices

One of the most serious things that appear to confront us today is high prices. If we knew that the present prices were to be maintained, that they would not drop back toward what they were before the war, we would have very little concern. We all know that there will be some falling off in prices, because war demands took up such a large supply of goods and labor as to force prices above their natural level. We may, however, be surprised and prices may not go back to their former level. Economists tell us that in general prices, after the Civil War, did not go to the level of what they were before the Civil War, and I venture to express the opinion that not for a very long time, if ever, will prices in general go back to the level they were before this world war. It would lead me too far to go into a discussion of the money question. The quantitative theory of money is pretty well established, and this theory teaches us that prices vary more or less directly with the per capita volume of circulating medium and whatever this circulating medium rests

upon. It is probable that the high prices in the United States are directly traceable, to a large extent, to the issue of Government bonds. These Government bonds are in the nature of extensions of credit, and extensions of credit are equivalent to an increase in the circulating medium. Germany has issued large quantities of paper money, and our associates in this great war have to some extent done the same. The Government bonds of our allies and our own country will form a basis of credit which, as I have said, is an increase of the circulating medium. High-priced labor means high prices for goods. If for no other reason, the resistance of labor to a reduction in wages will prevent, at least to some extent, a fall in prices.

For all these reasons I do not believe that the losses due to falling prices are going to be as great as some of us imagine. Of course the conservative business man has already taken care of this possibility, to a certain extent, by writing all of his inventories at low figures. How far he has been allowed to do this by the Treasury Department I am unable to say, but my understanding is that whether the Treasury Department would allow him to do this or not, in figuring his profits, it has allowed him to create such reserves as may be necessary to meet this condition. If reserves have not been created and profits have been divided on full war earnings, he is apt to be in a bad way and I know of no means of saving him without what would correspond to a surgical operation. If possible, reserves should be created in order to meet the possibility of lower prices.

High Wages

As I have already indicated, I do not feel that prices will fall very much or that wages will be very much lower. I am not considering here what we would want to do or what labor leaders want to do; I am only presenting my own diagnosis of the situation. If, however, wages do tend to go down, there will be something of a corresponding fall in prices. Each employer will have to consider the extent to which it is profitable to him to reduce his employees' wages. He has very little arbitrary power in this matter, but he can exercise a considerable amount of intelligence, and I personally believe that high-priced labor is more profitable than so-called cheap labor, although I do not mean by that that if you increase an employee's wages you thereby immediately increase his efficiency to a greater extent. I notice, however, that the men who are getting the highest wages usually get them because they are worth more than those who are getting less.

There will be a feeling of duty on the part of every employer of labor to take back those employees who have been in the Government service, finding positions for them as best they may. Many of these men who have served in the Army and Navy will come back with increased efficiency, unless indeed that efficiency is interfered with by injuries received. They will have a new view of life; they will be more democratic in their valuation of men than they were before. I am inclined to think that the men and women who have been in the service will have ideas that the intelligent employer cannot ignore. They will have become a political force of no small magnitude. Many of them have been fed by Uncle Sam better than they were ever fed before. In general their standards of living will have risen. The intelligent employer will not see his way clear arbitrarily to reduce wages. In view of these facts, the unintelligent employer, if he attempts to exercise his arbitrary power, will be confronted by strikes, without the support of public sentiment.

I do not know how to meet this problem of the wages of labor, except through a broad sympathetic spirit that says, "I may have to reduce wages and if I have to I suppose I shall, but as long as it is in my power not to do so, I will not do it."

I make this suggestion simply as a business proposition. There are enough things confronting us to disturb business conditions and we should not seek for other forms of trouble. Undoubtedly there have been a great many employees discharged, with more to follow. There will be a large number of possible employees released from the Army. There will be a freer labor market. But many of our industries have been very short of labor for a long time and this shortage has not been met as yet. There may be no surplus of labor. The demands of the world for labor's products show no abatement. With peace production so much curtailed and with the awful destruction of wealth during the last four years, it would appear that the demand for industrial products would be great for some years to come.

Organization of Chemical Industries

I have already indicated how, under the Webb law and through Open Price Associations, our chemical industries can become more highly organized. There is little I have to suggest beyond this. I have only this thought to add. I know of no industry that is so continuously changing as the chemical industry. It cannot stand still. It must either go forward or backward. To go forward there must be co-operation between our industries and our educational institutions, there must be more chemical research and more active drafting of men of technical education into the commercial world.

In conclusion let me add this further suggestion. Opportunities very seldom come knocking at our doors. They are usually met in the course of our search for definite things. The recognition of opportunity when one meets it is a measure of intelligence. Particularly is this true in chemical industries. Opportunity presents itself in the unexpected discovery of new products and in the unexpected discovery of new uses for relatively old products. Very often opportunity appears at first in the disguise of failure. In general the success of any business, or we might say everything, depends upon its opportunities, but it also depends upon their utilization.

What the future holds in store for us is largely a matter of opinion and my opinion makes me an optimist. I am optimistic as to the opportunities that lie before our chemical industries. I am optimistic that our chemical industries are managed by men of so high intelligence that the opportunities that lie before them will not be overlooked. The world is in a state of flux requiring the greatest agility of mind if legitimate profits are to be extracted. This agility of mind I believe we possess. The future can only determine whether I am right or wrong.

Being a Journey of Observation in England, Scotland, Belgium and France With a Party of Editors of American Technical and Business Papers, at the Invitation of the British Government

ONE of the Great War's products in the United States was a fine spirit of co-operation and helpfulness between the Government and the technical and business press of the country; in fact, the relationship became so intimate and satisfactory that the press was looked upon as one of the strong arms of the Government in accomplishing its purposes. It remained, however, for Great Britain, through its Ministry of Information, to crown this local recognition of the business press by inviting a party of fifteen editors and publishers of technical and business papers of the United States to visit England and France in order that civilian intercourse among those nations might continue in spite of the obstacles interposed by military regulations. The following representatives comprised the party:

Horace M. Swetland, President United Publishers' Corporation, New York.

Arthur J. Baldwin, Vice-President McGraw-Hill Co., New York.

H. C. Parmelee, Editor CHEMICAL AND METALLURGICAL ENGINEERING, New York.

Henry G. Lord, President *Textile World Journal*, New York.

Roger W. Allen, President New York Business Publishers' Association, Inc. *American Hatter, Millinery Trade Review*, and *Nugent's—The Garment Weekly*, New York.

David Beecroft, Directing Editor of the Class Journal Co., New York.

H. L. Aldrich, Publisher *Marine Engineering* and *The Boiler Maker*, New York.

Samuel O. Dunn, Editor *Railway Age*, Chicago.

William W. Macon, Managing Editor *The Iron Age*, New York.

Floyd W. Parsons, Editor *Coal Age*, New York.

H. E. Taylor, Business Manager *Dry Goods Economist*, New York.

Frederick F. Cutler, President *Shoe and Leather Reporter*, Boston.

H. Cole Estep, Editorial Director Penton Publishing Co., Cleveland.

Allen W. Clark, President American Paint Journal Co., St. Louis.

Edw. H. Darville, *Hardware Age*, New York.

Sailing from New York on the S. S. *Lapland*, Oct. 26, 1918. we left the United States under all the conditions of secrecy imposed by military regulations. Our ship carried about 2500 troops, a contingent of the Army Nurse Corps, some British officers who had been assisting in the campaign for the fourth Liberty Loan, and a small group of civilians. About 4 o'clock in the afternoon we dropped down the river to the lower bay, where we joined a number of other ships, all camouflaged like our own, and anchored for the night. The following morning we were joined by still other ships, and about noon the great *Leviathan* steamed past us, loaded with thousands of troops. During the rest of the day we were treated to the impressive and spectacular sight of a great fleet of between 50 and 60 vessels starting across the ocean with troops, munitions and supplies, as part of the great answer America was making to the Kaiser's sneering taunt that we wouldn't fight.

DESPATCHING A FLEET TO EUROPE

The precautions for safety taken in despatching that great fleet to sea were a matter of astonishment to all. Hydroplanes, submarine patrol boats, captive balloons, a dirigible and several destroyers paid incessant attention to the departing vessels. The air and water were filled with these small craft scurrying here and there, guarding against any surprise attack from a lurking enemy. For several hours we were thus attended as we put to sea; and all this was accompanied by incessant signaling from ship to ship, by semaphores, pennants, wigwagging and flashing lights. Long before dark the

THE AMERICAN EDITORS IN HOLYROOD PALACE, EDINBURGH

fast *Leviathan* had disappeared over the horizon, and the balance of the fleet had spread out in fan shape extending as far as the eye could reach. One could be pardoned a thrill of pride in this evidence of the extent to which our great war machine was working in conjunction with the Allies.

During the night the great fleet must have separated into smaller groups of vessels, because the next morning we were in a small fleet of 14 troopships and freighters, convoyed by a United States cruiser and a destroyer. The fleet was formed roughly in column of fours, with the cruiser leading and the destroyer in the rear. Our course was changed a few degrees about every seven minutes, and thus we zigzagged our way across the ocean.

The rules and regulations for passengers were evidence of the unusual conditions surrounding our voyage. Life jackets were either worn or kept in hand at all times; we were not allowed in the dining room without them, and they were in evidence at card games in the social room or at divine service on Sundays. No lights or smoking was permitted on deck after sundown, and no passengers were allowed on deck after 10 o'clock at night. Guards were posted throughout the ship as in a military camp; submarine lookouts were stationed at points of vantage; guns were mounted fore and aft, and depth-bomb guns on either side of the ship. The life-boats were swung out of their davits ready to be lowered instantly, and rope ladders were provided at frequent intervals along the deck for use in case it became necessary to abandon ship. Numerous life-rafts and collapsible boats were placed on the upper deck, all provided with fresh water and provisions. All troops and civilian passengers were assigned to numbered life-boats, and a drill was held twice daily to familiarize us with the procedure in case of accident. The civilian accustomed to ocean travel in peace times would not recognize his surroundings or comprehend readily the habits and customs of the ship's company.

The voyage was without any spectacular incident due

A GERMAN TANK AND OTHER TROPHIES IN PARIS

CHATEAU RADINGHEM, HEADQUARTERS FOR VISITORS

LOOT FROM THE CATHEDRAL IN DOUAI

A SILHOUETTE AT YPRES

to the menacing submarine. On one occasion a ship dropped out of our fleet, due to trouble of some kind, and disappeared over the horizon to the rear, attended by the destroyer. On the following morning both were in their accustomed places. At another time, when we were approaching the Irish coast, our course was abruptly changed 180 degrees for an hour or more, when we resumed the original course. Naturally there was never an intimation as to reason for these things and we remained in ignorance of their cause or purpose. As a matter of fact, we know now that the submarine menace had been practically eliminated at that time. The convoy system and the depth bomb had rendered the submarine of no avail against their most important targets—troopships and freighters. Credit for both these ideas is to be given to Admiral Jellicoe of the British Navy, whose resourcefulness and ability in devising these means of defense were publicly acknowledged by our Admiral Sims at a dinner given in our honor in London.

Convoyed by British Destroyers

Approaching the Irish coast and the recognized danger zone, renewed precautions were taken for our safety. Troops were brought out of the hold and made to sleep on deck. Our own cruiser and destroyer turned back and left us, and we were picked up by eight British destroyers that convoyed us to Liverpool. The sea was heavy and these light small craft bobbed about like corks; and one was impressed with the discomfort that must attend life on such boats. In fact it began to dawn on our minds that the sailors navigating the coast patrols, mine sweepers, destroyers and merchant vessels have played a part in this war that will not be generally appreciated. Someone who knows should write the story of these heroes, their constant devotion to duty under the most uncomfortable and dangerous conditions, and their refusal to be intimidated or deterred from returning to sea even after they had been torpedoed one or more times. About 5000 small craft have been engaged in this work of coast patrol, mine sweeping and convoying, cruising at times a total of 6,000,000 miles in a single month, and providing throughout the war for the safe carriage from all ports and in all directions of a total of 15,000,000 men.

We landed at Liverpool on Nov. 8, after a voyage of 13 days. Here we were met by military representatives of the Ministry of Information, Col. E. L'E. Malone and Major George Whitmore. The latter was to be our guide, mentor and friend for six weeks, making easy our path through England, Scotland, Belgium and France; attending to passports, hotel accommodations, railroad tickets, taxis, etc., and securing for us many courtesies wherever we went. As a result of his

PUBLIC SQUARE IN ARRAS

REPAIRING THE MENIN ROAD, BELGIUM

MARKING THE SITE OF A DESTROYED VILLAGE

efforts we escaped many of the difficulties of travel during war times, as well as the necessity of reporting to the police on arrival at and departure from a city. Hotel registration, however, he could not relieve us from, and it was always necessary to give our intimate personal and family history at each new hostelry.

Conditions in London

At Liverpool we were provided with a special car on the London & Northwestern and went directly to London, arriving there about 10 o'clock at night. Here we encountered new precautions for safety from German attack—this time from the air. London was dark. An occasional street lamp was lit but masked with paint, and taxis carried only a dim light. Illuminated red signs at frequent intervals along the street conveyed the cheerful information that "air raid shelter" could be found in some adjoining basement or subway station. The first sight that met my eyes when I looked from the hotel window on the following morning was an immense captive balloon, suggestive of the constant patrol of the air that had been maintained since air raids on defenseless cities first were instituted by the enemy.

London was also cold, partly because of a shortage of coal and partly because the central heating plant for large buildings is almost an unknown quantity. The wasteful and inefficient open fire-place still holds sway in hotels and office buildings. Poor enough in ordinary times when there is plenty of coal, this system becomes intolerable when fuel is strictly rationed. The experience should bring home to England the necessity for burning her fuel more economically and at the same time getting some satisfaction out of it.

It cannot be said that London was hungry, but food was strictly rationed. There was enough to eat and the food was good. It lacked variety and "frills." Fruit was scarce and expensive. Sugar was issued only on delivery of the proper coupon, and we carried a week's supply of lump sugar in our pockets. Meat also was served only on presentation of the ration card, from which the waiter clipped the necessary coupons, and if the week's allotment were used at one meal, no more was to be had the balance of the week. On every hand was the evidence that London's sole business and concern was the war and its successful conclusion. These were the conditions under which the city had pursued its war vocations for four long years, never doubting the ultimate triumph and asking only time enough to train men and produce munitions. I could not help being impressed with the fact that despite the tremendous effort America was making and the vital contribution she was offering to the winning of the war, nevertheless our people had not begun to understand what sacrifice meant. Our resources were of such extent that we met the demands on our time, ability and money almost without self-denial and certainly without great sacrifice. England, on the other hand, had paid a price that we in America could not comprehend without closer contact with the British people.

The Lord Mayor's Show and Armistice Day

The day following our arrival in London was the occasion of the Lord Mayor's Show, or inaugural parade. This is an ancient ceremonial, participated in by the different guilds or associations of artisans and workmen and the representatives of the city government. A decided military aspect was lent to the parade in 1918, every branch of the British forces being represented. Allied troops also participated, and it was noticeable that the company of United States infantry received greater applause as it marched along the route than did any other unit. This demonstration, we discovered later, was a fair indication of the esteem in which America and her troops were held by England. There was the deepest appreciation of our co-operation and assistance, and an expressed feeling that the splendid relations that had grown out of the war would continue to animate the two nations in their future dealings with each other, as well as in their efforts to solve world problems.

Within three days of our arrival in London armistice was declared, an event which was jocularly referred to as additional evidence of the power of the business press of America. Either Paris, London or New York would have been wonderful places in which to observe the celebration of the armistice, but I shall always be glad that I saw it in London. The city gave itself over to the most unrestrained rejoicing. At 11 o'clock on that eventful day the explosion of the maroons announced the glad news. Within five minutes I was in the Strand, thrilled at the sight. Women, old and young,

ROAD IN FLANDERS

married and unmarried, swarmed into the street from the buildings in which they were working. With tears streaming down their faces, which at the same time were broken into smiles, they paraded, danced, sang and cheered. Not one of them but had felt the sting of war or the loss of some male member of their families, and the pent-up emotion of four long years was not to be restrained on receipt of the good news of the end of hostilities. The crowds gathered until traffic was impossible. A band of Scotch pipers appeared, followed by a long line of paraders. People rode on the hoods and fenders of the buses and taxis, and commandeered trucks and automobiles. Flags and colors appeared in such profusion that the city soon wore a holiday appearance.

A TRENCH IN FLANDERS

Business was suspended and the crowds of merrymakers owned the town. The London "bobby," wise in his day, stood aside and let the crowd have its way, well knowing that the celebration would be orderly. As a matter of fact, the only disorder of the week was the burning of some captured German artillery which was hauled to Trafalgar Square and made into a huge bonfire.

England's Reception to the Technical Press

Our first week in England might be described as reception week. The Ministry of Information had made elaborate arrangements for the business editors of the United States to meet and become acquainted with the leaders of British thought and opinion. Many of these meetings were arranged under the most delightful circumstances, such as the dinner and afternoon at the country place of the Duke of Sutherland near Guildford. Here were assembled a group of English men and women who were engaged in war work of various kinds, as members of Parliament, officers in the Army—workers in hospitals, inns for officers on leave, etc. The conversation turned to intimate phases of life and war work in the two countries and gave each an opportunity to understand better than ever before just what was in the heart and purpose of each nation and how each was trying to accomplish the desired end.

A formal luncheon by the Ministry of Information came by chance on Armistice Day, which gave a new aspect to our reception. Other luncheons and dinners followed in rapid succession: by the English-Speaking Union, the British Newspaper Conference, Sir George Perley, Lord Burnham, the National Trade Press, General Smuts and the American Chamber of Commerce in London. These were attended by eminent statesmen and representatives of industry in Great Britain, and their utterances on those occasions were reported in full in the daily press of London.

The English-Speaking Union is an organization the purpose of which is sufficiently indicated by its name. With the Rt. Hon. Arthur J. Balfour as its president, it is composed of the leading thinkers of Great Britain who are desirous of bringing about a closer relation between the English-speaking peoples of the world. At our luncheon Sir Arthur Steel-Maitland presided, and we were addressed by Mr. John Hodge, Minister of Pensions, and Major Evelyn Wrench. Others in attendance were Sir Gilbert Parker, Lord Desborough, Sir Campbell Stuart and American Consul General Skinner. Cables of congratulation were despatched by the Union that day to Marshal Foch, Field Marshal Haig, Admiral Wemyss and General Pershing.

At the dinner of the British Newspaper Conference the principal speakers were Mr. Balfour and our own Admiral Sims. The dinner by Lord Burnham, owner of the London *Telegraph*, was a brilliant function at Claridge's, attended by Winston Churchill, Sir Frederick Smith, Sir Arthur Pearson, the Lord Mayor of London and some of the other city officials, Raemakers the cartoonist and other notable people. It was on this occasion that Sir Frederick Smith told of the desperate situation in France in the spring of 1918, when plans were made to salvage whatever was possible of the British forces and supplies in France and begin preparations for a still longer war before victory should be won. At no time was there a thought of defeat, but only terrible and costly delay in the final accomplishment. The British fleet was always the strong reserve arm of the empire, and could be relied upon to protect the homeland and keep the seas open until men and supplies could again be marshalled in sufficient numbers to gain the victory. Winston Churchill spoke feelingly of America's aid in the war, characterizing our intervention as "the greatest mental effort and spiritual realization of truth which has occurred in the whole course of secular history."

Mr. Churchill on British Sea Power

Mr. Churchill spoke again at the luncheon of the National Trade Press, and paid his respects to those who deprecate British supremacy of the seas. Sea power is vital to England and her colonial possessions, he said, and could not be minimized without jeopardizing the integrity of the empire. With regard to future military and naval preparations by the nations of the world, Mr. Churchill proposed an international register of all naval, aërial and military plans, and an international commission of inspection to see that no secret preparations are made.

One of the most interesting and important functions was the dinner given by Lt. Gen. J. T. Smuts, a Boer who had fought Great Britain in South Africa in the Boer war, but who was now in the British forces and a member of the Supreme War Council of five. Gen. Smuts had cleaned up German East Africa before coming to London, and had shown his loyalty to the principles of Great Britain despite his "slight difference with

that country some years ago." In the course of a statesmanlike speech, he paid tribute to the beneficent régime which Britain has always endeavored to establish in her colonies and over conquered peoples. One could but contrast the attitude of those peoples who have been conquered by the Germans during the past four years. Admiral Jellicoe, Arnold Bennett, Lord Islington and other distinguished gentlemen attended this dinner.

Despite the appearance of a round of social pleasures which this succession of functions suggests, there was a serious purpose in all of it, and the luncheons and dinners were merely the medium chosen for its accomplishment. It was a tribute to the technical and business press of America of which we may well be proud.

St. Dunstans, a School for Blind Soldiers

During this first week we found time also to visit St. Dunstans, a school for blind soldiers; the Y. M. C. A., Eagle hut and officers' inns, and other places of interest. St. Dunstans holds unusual interest because it is making independent, self-sustaining, useful men out of blinded soldiers. The grounds and buildings were loaned for the purpose by Mr. Otto Kahn of New York, and the organization of the teaching force, etc., was arranged by Sir Arthur Pearson, himself blind for the past few years. The psychology of the institution as presented to a blinded soldier just entering may be expressed about as follows: "You are not blind and therefore helpless; you have merely lost one of your five senses, and you still have four that you know little or nothing about. They can be trained so that you can be an independent and useful member of society." A story of wonderful human interest could be written about this institution, which practically embodies the common sense of an intelligent man who knew that it was possible for a man to lose his sight and yet preserve his independence.

A Visit to the Grand Fleet

The Grand Fleet of the British Navy is a powerful agent for peace or war. In years past it has been both, no doubt, but during the last four years especially it has been the greatest silent potential force of the Allies in their struggle against German world domination. Knowing something of the majesty of this arm of the British defense, we were delighted to have an opportunity to visit the fleet. Our course lay by rail to Edinburgh, and thence by motor to Rosyth, where the fleet lay in the Firth of Forth. Fog prevented our getting a view of the entire fleet at one time, but we rode in a motor launch up and down the lines of dreadnoughts, battleships and cruisers, all lying at anchor inside the famous Forth bridge. A few battleships of the American squadron were lying just outside the bridge. We were received on board the *Orion* by Admiral Goodenough and the ship's officers, and subsequently divided into parties for dinner on several of the battleships, the party of which I was a member going to the *Monarch*, where Capt. Drury-Lowe and his staff received us most cordially. After dinner we inspected the ship from fighting-top to engine room, and observed in action the mechanism for loading and firing the big guns in the turrets. Returning to the *Orion* we were all taken to the *New Zealand*, and after a brief inspection and reception we returned to shore.

CATHEDRAL AT ARRAS

Our visit was just two days prior to the surrender of the German fleet, and the British officers were anticipating the event with mingled feelings of satisfaction and regret. They would much rather have sunk the enemy in a fair engagement, and considering their four long years of vigilant watch, one could not deny them the wish that they might have met their enemy in an open fight. I think they still hoped, and maybe suspected, that the enemy would not surrender without a show of force, but they were all ready to meet him.

The Lord Provost and Corporation of Edinburgh tendered us a dinner at the City Chambers, where we met the leading men of the city. Arrangements were made for a special visit to the famous Castle, under command of Sir Robert Moncrieffe, and to all the apartments in Holyrood Palace. These historic places held a world of interest for us and recalled forgotten incidents in English history, particularly of that ill-starred personage Mary Queen of Scots.

At Glasgow we visited the great shipbuilding works on the Clyde, particularly those of William Beardmore & Co., Ltd. This plant was devoted entirely to war work, not only in the construction of ships, but in the manufacture of big guns and shells, airplanes and airships. These side issues were undertaken without any previous experience or preparation, and the success of the work is a tribute to the management. We found some labor conditions that to us were unusual. Hours of labor, for instance, surprised us. The men go to work at 6 a.m. and work until 9, when they stop for breakfast, resuming again at 9:45. A noon hour is taken at 12:30, and work is stopped about 5:30 or

6 p.m. It was admitted that the first three hours of the day's work were very inefficient, and that a straight 8-hour day would be better. To us it seemed as though a man could not be efficient if he went to work cold and hungry, with a prospect of three hours work before eating. A luncheon given us by the staff of Beardmore's gave an opportunity to discuss a number of industrial problems and compare notes on conditions at home and abroad.

That evening we were the guests of the Lord Provost and Corporation of Glasgow at a dinner at the City Chambers, where we met not only the city officials but some of the leading educators and thinkers of the community. The speeches disclosed the Scot at his best, particularly Bailie John Muir, whose homely philosophy and keen wit received sincere applause.

Armistice Prevents Bombing of Berlin

Returning to London, we visited the Handley-Page airplane factory primarily to accept an invitation for a flight, but this was prevented by a fog. We had the pleasure, however, of climbing into and inspecting a special plane which had been built to bomb Berlin, and which was to have left on its mission on Nov. 13, two days after armistice was declared. This machine has a wing spread of 127 ft., a carrying capacity of 14 tons, four engines aggregating 1400 hp., tanks for 1500 gal. of gasoline, two pits for rapid-fire guns, one fore and the other aft, and storage for five tons of bombs. The great regret of the air forces of Great Britain was that the preparations for retaliation were not advanced swiftly enough to permit the bombing of Berlin before the war ended. It was the great regret of our party that London fog was so persistent that we were unable to make a flight in London or to carry out the plan for flying across the Channel from England to France.

A Visit to Hadfield's

Although the Ministry of Munitions promptly closed all plants to visitors when armistice was declared, it was possible to visit one or two. Unfortunately we were not allowed to enter any of the great munition plants such as Gretna. There was the most cordial and free interchange of information between England and the United States while the war was on, but the practice stopped rather abruptly with the end of hostilities. Several of our party who were interested in metallurgy went to Sheffield and visited the steel works of Sir Robert Hadfield. The plant, like others throughout the country, had been greatly increased in size for the manufacture of guns and shells. An indication of one of the problems in the machine-tool trade was found in the fact that Hadfield's alone would discard 1000 lathes for which they had no use in peace times. Women had been largely employed in the plant, working at the lathes and at lighter work around the shops. At a later visit with Sir Robert Hadfield in his London home we learned something of the work his company had done in the development of manganese steel helmets and body armor. The former were superior to those used by some of the other nations, and while the latter were effective as far as protection was concerned, they were not practically useful. We saw specimens of helmets and armor that had successfully resisted rifle fire comparable to that which would be encountered in warfare. We were also given a private view of Britain's accomplishments in the line of super-shells and guns. They were not used in actual combat, but had been built and tested, and could have been put to work if occasion had demanded.

Technical Man Awaits Appreciation in England

A too brief visit to Sheffield University allowed me an hour with Prof. J. O. Arnold, who is at the head of the department of metallurgy and engineering. It is greatly to be regretted that work such as Prof. Arnold has done and is doing is not adequately supported. It seemed to me as though England had not yet risen to an appreciation of her technical men, despite the fact that they were the ones on whom she had to call when she was confronted by a foe skilled in technology and the application of science in the art of warfare. I was told that the Government had actually contemplated providing chemists for some of its works with the munificent salary of £125, about $625, per annum, a sum which would not attract a bottle washer in our American laboratories. This was but one instance of what seemed to me to be a lack of appreciation of technical education, but I was told that a change is coming and that England is alive to the needs of research, co-ordination of industry and universities, and the value of technology in the national life. Incidentally, some excellent work has been done by such men as Prof. Arnold and Sir Robert Hadfield, and we may expect some good papers from their pens.

One of those delightful informal social events that marked our stay in England was our entertainment by Sir Thomas Lipton at his home near London. We motored out in time for dinner, spent a delightful afternoon and returned after tea. Sir Thomas, of course, is known as one of the world's greatest sportsmen. His charming Irish wit and manner, coupled with his whole-souled love of sport, make him an ideal host. He told us of his hopes, which we learned later had been blasted, for a yacht race with America in 1919, and he gave us all shamrock pins which we promised to wear when the race was run. Sir Thomas has been heart and soul in the war and has done a fine work in his support of the Red Cross. On the occasion of our visit he invited Sir Andrew Weir, Surveyor General, who has charge of the purchase of Government supplies, to meet and talk with us.

Lord Northcliffe Entertains

Before leaving England we were entertained at luncheon by Lord Northcliffe, owner of the London *Times*, at Printing House Square. For this occasion our host had invited leaders of industry and political thought to meet and talk with us, and we counted the affair one of the most instructive we had attended. Sir Robert Hadfield spoke of the possibility of giving workmen a summer holiday with pay instead of making them take their holidays on their own time. Mr. W. L. Hichens, chairman of Cammel Laird & Co., spoke of his desire to improve the condition of the worker, maintain his high wages and reduce his working hours. To do this, he said, would require more money on the part of the capitalist and more work from the worker. Both labor and capital must see that they are going to profit out of

CONDITIONS IN THE COAL MINING REGION OF LENS

the improved order of things, and the community is to be the final judge of whether they are profiting enough or too much; neither should be allowed to hold the community up for ransom. He felt that the principle that "Might is Right" is what we have been fighting against in the war just closed, and that the principle was not acceptable in industry any more than it was among nations. Other speakers at the luncheon voiced interesting views on the problems that were confronting the nations of the world; all were optimistic, but earnest in the belief that the times demand new methods and ideas.

The Battlefields of France

The English Channel is proverbially a difficult piece of water for poor sailors to cross, but we were kindly treated to a comparatively smooth sea when our party crossed from Folkestone to Boulogne. Before we were able to leave London for France we were obliged to spend several very good and precious hours getting passports properly stamped. War-time travel is beset with difficulties enough to deter any but those for whom the way is smoothed as it was for us. Other civilian travelers who had not the kindly arm of the British Government about them were subjected to much delay and annoyance trying to prove their identity and show the necessity for travel between the two countries. We were practically the only civilian passengers on the boat leaving Folkestone. Arriving at Boulogne we were met by military representatives of the Ministry of Information, who took us immediately by auto to the château at Radinghem which had been provided as headquarters for American visitors. The château is a thirteenth-century structure, with moat and drawbridge, which had been fitted with some modern conveniences. Here we were comfortably quartered for several days while we made daily automobile trips of about 150 miles to various parts of the battlefront which had been lately abandoned.

Our hosts at the château were British officers who were familiar with the military history of the ground to be covered, and each night we received a brief lecture on the points to be visited the following day. Military maps were provided on which the route could be traced and points of interest noted.

Our first day's trip took us to Bethune, La Bassée, Lille, Menin, Ypres, Poperinghe, Steenvoorde, Hazebroucke. The terrific effect of modern shell fire was evident at all of these places. Our first introduction to it was at Bethune, but it was at La Bassée that we saw it at its worst. La Bassée literally has not two bricks held together by the original mortar. Houses, store buildings and churches are piles of brickbats and rubbish. Here and there we saw great concrete gun foundations and shelters, reinforced with steel. The walls and roofs of these structures were four feet thick, and the foundations much heavier. There was a great deal of this concrete work throughout the country occupied by the German forces, and the magnitude of the work recalled the quarrel that Germany had with Holland

regarding the transportation of sand and gravel across the latter country. Germany professed at the time that the material was altogether for peaceful purposes.

Devastation in the Battle Area

The destruction of cities and towns in France is so complete along the line of battle that one place looks much like another and no powers of description can enable the reader to visualize the wreckage. Occasionally small towns have been so completely wiped out that the place on the road is marked by a sign post informing the traveler, for example, that "This is Souchez." In some of the illustrations accompanying this article I have tried to give an idea of the destruction of cities, the churning of the ground by high-explosive shells, the nature of barbed-wire entanglements and trenches, etc., which are much alike throughout the length of the battlefront.

The city of Lille was not damaged by bombardment, being held by the Germans throughout the war, but when it was evacuated the bridges were destroyed at every approach to the walled city.

We crossed the Lys into Belgium at Halluin and Menin and took the Menin road to Ypres. This was the most desolate spot I have ever seen, uninhabited and uninhabitable, filled with trenches and lines of barbed wire, pitted and scarred with shell craters that were partly filled with water. The trenches in this section, in front of Ypres, were shallow and the dugouts were filled with water. At one place we saw an abandoned contractor's

CAPTURED GERMAN GUNS IN PARIS

pump that had been used to keep a dugout reasonably free from water. It was inconceivable that men could withstand the hardships of such a life as they had to live here.

Entering Ypres by the Menin gate, we traversed a part of the city and saw the ruins of the famous Cloth Hall and the cathedral, both damaged beyond repair. Although this city was never taken by the Germans, it was shelled from three sides and was practically destroyed.

Wanton Pillage of Douai

On our second day out from the château we went to Arras, Douai, Lens, Vimy Ridge and other places of less importance. Douai roused our ire more than anything we had seen because it showed the effects of wanton destruction and pillage by the Germans. Externally Douai presents the appearance of any city outside the war zone, but within its houses, stores and churches are the evidences of vandalism, plundering and despoliation, What could not be carried away by the Germans as booty was destroyed. Oil paintings were ripped from their frames, mattresses cut open and dumped on the floor, books swept from their cases and china from the cupboards, plumbing and all metal work ripped out and taken away. We found M. Paul Robaut, general secretary for the French Red Cross in Douai, whose home had been used for a long time as headquarters for the German Red Cross. He was deported from the city last September with all other inhabitants, and when he returned he found his beautiful home in such a condition of destruction as could not have been accomplished by earthquake and cyclone. Nothing but the hands of an army of German soldiers sacked Douai and left it in its present pitiable condition. Here also in one of the houses that had been used as German billets we found a German saw-tooth bayonet, a wicked instrument. We left this place thoroughly convinced that any distinction between the German people and their rulers was quite unnecessary.

The coal-mining region of Lens also presented a scene of destruction that could be accomplished only by the hands of fiends. No one knows what may be the condition of the coal mines of Lens. It is reported that they were dynamited by the Germans before they were abandoned, and that they have since filled with water. As the mines are deep and the veins narrow, it may be impossible to recover them through the present shafts. Certain it is that all surface workings have been destroyed beyond repair and the villages of the region rendered uninhabitable. The first step toward rehabilitation will have to be shelter for the workmen.

Vimy Ridge was an impressive battlefield, for it could be seen how certain death must follow the order to cross the narrow valley and assault the ridge held by the Germans. Quantities of ammunition still were stored by the roadside in huge dumps, and there was evidence of the fiercest fighting.

On the Hindenburg Line

The third day's ride took us to Albert, Bapaume and the Hindenburg Line and Canal du Nord on the road between Bapaume and Cambrai. At one point on the limestone road we saw an impressive sign "Dust Draws Hell Fire—Go Slow." Closer examination showed that originally it had read "Shell Fire," but the erasure of the S had left the sign fully as significant and appropriate as it was originally. The sign had been placed there as a caution to truck drivers in the army trains.

We spent some time at the Hindenburg Line, examining the trenches and dugouts. The latter were quite comfortable, and the line as a whole looked almost impregnable. Tanks, however, were more than equal to this line of defense, and we saw the tracks of these monstrous engines as they had forced their way over trenches, barbed wire, shell craters and obstacles of all kinds. In tank construction and operation the Allies far excelled the Germans; the British counted them their greatest achievement in land offense.

Leaving the château and our British hosts, we went to Paris. There was a marked difference in some fundamental conditions in Paris as compared with Lon-

don. Food was more plentiful and in greater variety, although it was also more expensive. Fruit was available in better quality, but at several times the price in London. Meat could be secured without ration cards, but bread tickets were necessary if one cared for bread regularly. Paris was warm, too, and this in spite of the fact that coal was scarcer than in England. This was due largely to the fact that there are central heating plants in the hotels and large buildings, insuring more efficient combustion of the fuel.

The President in Paris

We were in Paris when President Wilson arrived, and witnessed the genuine and sincere demonstration which greeted him. The English and French people were deeply interested in his coming, and we repeatedly heard expressions of astonishment at the opposition to his trip which developed in America. To them Mr. Wilson embodies our great nation and the vital assistance which we rendered at a critical moment, and it seemed to them most logical that as the head of our nation he should participate in the negotiations for peace. Furthermore his idealism appeals to the French; and in England also we heard many expressions of approval of the ideas and ideals he has advanced. His arrival in Paris was the signal for a demonstration which lasted far into the night. There were parades with banners bearing the inscription "Vive la Paix Wilson," and many other demonstrations of approval of the President of the American republic.

Only one industrial plant was open to us in France, that of Andre Citroën in Paris. This is a modern munition plant for making the French 75-mm. shells. It is equipped with American machine tools and laid out on modern lines. Considerable attention is paid to the welfare and working conditions of the employees, of whom there were 12,000. Women were employed to the number of 8000. There was a dining room seating 3500, and rest rooms where employees could take recreation during the day. Complete laboratories for chemistry, metallography and physical testing were an important part of this modern plant. Women were employed in the laboratories, holding assistant positions. Men's wages were $5 to $6 per day, and women's $3 to $4, being about twice the wages of four or five years ago.

A trip to Versailles gave us an opportunity to visit the Palace, and see the Galerie des Glaces, in which the final sessions of the Peace Conference are to be held. It was in this room that the great German Empire was formed years ago, and here it will receive its finishing touches at the hands of the Allies. En route to Versailles we stopped at the Hôtel des Invalides, where the war museum was opened to our inspection, and special permission was granted to visit the tomb of Napoleon. The latter was still encased in the sandbags that had been placed around it as protection from aërial bombs.

Champagne Cellars at Rheims

Further visits to the battlefield were made from Paris under the escort of French officers representing the French High Commission. Noyon, Rheims and Berry au Bac were thus visited. Each had its special interest which cannot be described at length here. At Rheims there was the famous cathedral, still beautiful in its ruins. We were informed that it can be restored, and we presume it will be in due time. The Pommery champagne cellars at Rheims were also an object of satisfied curiosity. These cellars are but part of great limestone workings that underlie the entire city, extending for an aggregate distance of 60 miles. The Pommery cellars alone are 12 miles in extent. French troops were quartered in these cellars during the war, and moved from one part of the city to another without observation. We were told that Pommery cellars contained 8,000,000 bottles of champagne and that 60,000,000 was the total number in the cellars of the city.

The battlefield of Berry au Bac was notable for the fighting about Hill 108, and for the engagement of 80 tanks in a French assault on the German line of trenches. The assault was successful in that the trenches were taken, but when the tanks proceeded beyond the line and exposed themselves to direct gun fire in the open, they met with disaster and only 40 escaped destruction. Forty great hulks were still on the field when we were there, helpless looking machines when disabled by heavy gun fire, although very effective in assaulting infantry lines.

The King of Saxony's Dugout

The dugouts at Berry au Bac were the most elaborate in extent and equipment of all that we saw. They formed a continuous line of communication thirty feet beneath the trenches for a distance of about two miles. In one of them, reputed to be the underground dwelling of the King of Saxony during his occupation of that part of the line, we found a fine brick mantel and fireplace, desk, chairs, mirror, bed and evidences of telephone and electric light connections. Our conductor on this occasion, Lieut. Verdier, had fought at this point and was able to give us a very interesting account of the engagement.

For a few days we were in the hands of American officers at the visitors' quarters at Neufchâteau, and from this point made a one-day trip by auto, about 160 miles, into the city of Metz. The principal items of interest were the overturned monuments of the German Emperors, the supercilious statue of the late Kaiser among the prophets on the great cathedral at Metz, and the external evidences of damage that had been wrought on the property of German sympathizers. Store signs were being changed from German to French, and there was every evidence that it would be both popular and profitable to be French or at least a French sympathizer.

France's Disabled Industries

France gives one the impression of being somewhat dazed over her recent experience, and at a loss to know just where to begin to retrieve her lost fortunes. We had a number of dinners and luncheons with their leaders of industry, who said frankly that France was in the position of having to ask preferential treatment at the hands of the other nations. One gentleman even suggested that they would like to see French goods enter the United States duty-free, and American goods pay a duty on entering France. They are alarmed at the prospect of the Germans capturing world markets before France can even rehabilitate her factories and get new machinery in running order. The Germans return

to factories that are intact, ready to turn out their products into world trade, while France must begin at the bottom and build again her principal industries. These are the things that worry France and are probably having something to do with the new terms in the extension of the armistice period.

Returning to England from France, we spent a few days in London, during which time we were entertained at tea in Stationers Hall by the Circle of Scientific, Technical and Trade Editors. This is an organization that is striving to raise the standard of editorial work and the status of the editor in England. An exchange of views for an hour or more was profitable to all of us.

The Ministry of Information gave us a farewell luncheon in London on Dec. 19, and on Dec. 22 we sailed from Liverpool on the S. S. *Carmania*. The return voyage was made without the precautions that attended our trip eastward, although life-jackets were still recommended and a boat drill was held. Our ship carried mine sweepers on either side near the bow. We were carrying about 3000 Canadian troops bound for Halifax, and on reaching that port we secured shore leave so that we might see the results of the terrific explosion in the harbor in December, 1917. We also had an opportunity to inspect the new $35,000,000 water and railroad terminal which the Government is constructing. The balance of trip down to New York was uneventful, and we landed on New Year's Day, glad that our home is in the U. S. A., but not forgetting the ties that must inevitably bind us closer to our English-speaking friends on the other side. One cannot experience two months of travel in foreign lands and contact with peoples with whom we have been united in a vital struggle without getting a new point of view, broader, larger, more comprehensive and sympathetic. We have been deeply impressed with the endurance and fortitude of the British and French, and we can but admire the high ideals that animate them in their approach to the solution of problems that concern the world's future welfare. Our own participation has been deeply appreciated, so much so that we are likely to be led into exaggeration of the importance of our part in the great struggle. At the same time our help is just as urgently sought in meeting the problems of peace, and to that end we must all lend sympathetic and broadminded aid.

Two Great Problems

There are two great problems in which we are interested: The reconstruction of French and Belgian industries, and the reparation by Germany for the destruction of life and property. Reconstruction will come slowly because there are human problems of shelter and sustenance to be solved before factories and shops and works are rebuilt. Some cities may not be rehabilitated; new sites will be chosen after due study by a central organization in Paris. Reparation, of course, must be made by Germany to the fullest extent. The German nation today is an unrepentant and unchastened people, but perhaps the size of the bill to be paid may awaken them to the enormity of their crimes against civilization. There is no need for leniency or magnanimity in itemizing the bill or exacting its full payment. The Germans are resourceful and frugal. They have learned the lesson of self-denial and saving, and they can continue in these habits and apply the product to the expiation of their crimes.

The bill will be large, but time can be allowed for its payment in full.

Synopsis of Recent Chemical and Metallurgical Literature

Die Casting of Aluminium Bronze.—H. RIX and H. WHITAKER of the British Westinghouse Co. read a paper on the above title before the March, 1918, meeting of the Institute of Metals. They point out the advantages of die castings as follows: Die castings are uniform and accurate to 0.005 in. or less; they eliminate machining and they allow a high, continuous output. The cost of the casting should be analyzed, adding the proportional cost of the die, which is apt to be very large, in making a comparison to the sand casting, where machining must be added. Die castings were made more than twenty years ago of low-melting white metals. The many advantages of aluminium have been nullified by its high melting point; by the fact that it attacks iron when hot, thus reducing the life of the dies to as low as two thousand casts; by its weakness when hot and by its high shrinkage. The latter has been reduced to 1.4 per cent by proper alloying.

Successful castings in quantity are made by the authors using bronzes containing from 7 to 10 per cent aluminium and 1 to 4 per cent iron. The effect of the iron is important. Some iron and aluminium enter into solid solution with the copper, forming the alpha-constituent, but the bulk of it probably separates out as a high-melting point compound like $FeAl_3$, which forms a skeleton in which the residual metal solidifies. This refractory skeleton thus reduces the shrinkage and produces a fine grain. The iron also increases the yield point and ultimate strength at the expense of ductility. The properties of the finished casting vary with the heat treatment, the speed of cooling, the temperature of the metal, of the mold, and of stripping. Fortunately the above alloys show no beta-constituent; therefore it is not so responsive to heat treatment as though this metal were present. The alloy cast in a 1-in. chill gives the following tests:

Diameter of test section, in.	0.564
Yield point, lb. per sq.in.	29,400
Ultimate tensile strength, lb.	71,000
Elongation in 2 in., per cent.	24
Reduction of area, per cent.	21.8

For a scientific investigation into die casting, the authors point out the following points for study in the alloy to be used: Its coefficient of expansion at different temperatures, fluid and solid; its specific heat; its thermal conductivity; its mechanical properties at high temperatures; its mass, volume and surface area when cast; its latent heat of fusion; its metallography; its pressure on the die, and its fluidity.

The discussion of the paper brought out the fact that the iron should be added to the alloy as pure wrought iron chips, silicon in the addition being fatal. The metal should be melted at as low a temperature as possible and properly killed, the melting practice being responsible for many blowholes and other defects. The cores should be removed at the right time so that by shrinkage the solidifying metal about them might not rupture through setting up internal strains. In some cases the handling of cores was so difficult that openings could be more cheaply machined. Bottom gating gives a flow of metal which has a cleaning effect on the molds, but which requires more gates, vents and risers. Aluminium in alloys seems to protect the cast iron dies by the formation of a skin of alumina; this is quite an advantage over brass, as the latter forms a zinc oxide coating which must be carefully cleaned out between casts. Success in die casting involves starting with relatively simple forms, and then the expenditure of much capital, patience and brains in working to more complicated castings.

The approved material for dies is a chill-cast block of close-grained, gray cast iron, as hard as can be machined. Two analyses quoted were:

	Per Cent	Per Cent
Combined carbon	0.14	0.84
Graphitic carbon	3.35	2.76
Silicon	2.40	2.02
Manganese	0.43	0.29
Sulphur	0.10	0.07
Phosphorus	1.3	0.89

The latter is perhaps a little high in combined carbon, as this element causes growth and deformation in the hot die. The former is also too high in phosphorus. A well made die with these specifications will stand from five to seven thousand casts with the aluminium bronze under discussion, and then fail by the development of small cracks at right angles to the axis of the piece, especially where there is the largest heat transfer. No facing is required, the fine particles of graphite in the metal effectually acting as a lubricant. This graphitic sponge also allows the ferrite matrix to expand more readily and with less internal stress than would be the case in a close grained block of steel or nickel. No special cooling of such dies is required. Each casting is matter of individual study—for that matter, different alloys may not be cast successfully in the same die, owing to their different requirements in shrinkage, gating, etc. About the only advice which can be given as to the design of dies is that the mass of the metal should be such that the rate of cooling of the contained liquid metal should be at the same rate in all parts. The core-plugs are made of chrome-tungsten steel, and are dipped in graphite wash after they are withdrawn, but even so they last only from one-half to one-third as long as the die.

Evaporation of Small Spheres.—IRVING LANGMUIR (*Physical Review*, Vol. 12, p. 368) assumes that evaporation of small objects in air should be closely related to the convection of heat from bodies of the same shape. Previous researches on the latter (ibid., series I, vol. 34, p. 401) had shown him that the loss of heat from small wires consists essentially of conduction through a film of relatively stationary gas around the wire. Thus he believes that the air in contact with small evaporating spheres (of iodine, for instance) is saturated, that the exchange of molecules between the solid and its surrounding vapor is very rapid compared with the rate at which the vapor can diffuse away through the air and that no allowance need be made for air currents. On this basis a formula is developed which shows that the rate of evaporation is proportional to the radius of the sphere—as previously determined experimentally by H. W. Morse—and from which, using Morse's results, the diffusion coefficient of iodine vapor in air at 20 deg. C. is calculated to be 0.053, a figure in harmony with known coefficients for vapors of high molecular weights.

Convention of National Foreign Trade Council

The National Foreign Trade Council will hold its sixth national foreign trade convention at the Congress Hotel, Chicago, on Thursday, Friday and Saturday, April 24, 25 and 26, 1919. The formal call will be issued shortly by the chairman of the council, Mr. James A. Farrell, president of the United States Steel Corporation. The convention will deal with foreign trade as a factor in stabilizing American industry—problems involving the conversion of war industries to the needs of peace; development of our foreign trade to provide employment for our soldiers, sailors, and war workers; and the formation of a definite policy dealing with the future of our new shipping.

Imports and Exports of Gold and Silver

The Bureau of Foreign and Domestic Commerce reports that imports as well as exports of gold continued to decrease during the latter part of 1918, the imports amounting to $62,000,000 in the calendar year, against $552,000,000 in 1917, and the exports to $41,000,000, against $372,000,000. Imports of silver increased from $53,000,000 in 1917 to $71,000,000 in 1918. The exports of silver during December, 1918, amounted to $48,000,000, a larger amount than in any month during the past three years. For the calendar year 1918, exports of silver amounted to $253,000,000, against $84,000,000 in 1917.

Employees of Copper Companies to Meet Secretary of Labor

The Secretary of Labor invited the grievance committee of employees of all the copper companies operating in Arizona and representatives of labor in Utah and Montana to send delegates to confer with him in Washington on Jan. 31 regarding labor conditions in the copper districts. The copper industry is confronted with grave conditions owing to the reduction of output and employment, and it is the purpose of the Department of Labor to cooperate in securing the best working conditions during the period of readjustment.

Meeting of the Canadian Mining Institute

The Canadian Mining Institute will hold its twenty-first annual meeting at Montreal, Canada, March 5 to 7. A special invitation has been extended to the members of the American Institute of Mining Engineers to attend and participate in this meeting. March 6 will be American Institute of Mining Engineers day. As at the New York meeting of the A. I. M. E. in February, there will be a discussion on international co-operation in mining and uniform mining law for North America at the C. M. I. in March.

Book Reviews

THE ZINC INDUSTRY, By *Ernest A. Smith*, Assoc. R. S. M. 211 pages, illus. Price $3.50. New York: Longmans, Green & Co.

This is one of the excellent "Monographs on Industrial Chemistry" edited by Sir Edward Thorpe, designed to give the average reader a clear view of certain important manufacturing processes as influenced by chemical phenomena. Therefore, while this particular book does not attempt to present the details of mining, metallurgy and selling, more ambitious writers could do well to present their material in a manner as clear and inclusive. For instance, it contains well selected and easily understood data on the metallography of pure zinc and its common alloys, even including the more modern zinc-base die casting compositions. In view of the economic and commercial aspect of the metal, the author is necessarily influenced by his British citizenship; a foreshortened view of the technology is fortunately easy to avoid. In the chapter "The Rise and Progress of the Production" is an instance of the oft-recurring cycle of events. One notes the fact that the manufacture of brass from liquid zinc was long neglected for the ancient process of cementation by calamine, until finally the Prussian industry in 1825 (pointing the way for the American Zinc Institute) offered prizes for the discovery of new uses for zinc metal. American producers would also profit from the pre-war decadent condition of the British spelter industry as compared with that on the Continent, due, as the author states, to neglect of modern progress in plant design, to a lack of scientific control of the process, to the absence of co-operation among producers, and to the failure to build and maintain an adequate supply of skilled workmen.

* * *

BIBLIOGRAPHY OF FOREIGN TRADE PUBLICATIONS. By *Herbert Stanley Shuey*. 78 pages. Price $1.50. San Francisco: The ten Bosch Co.

This compilation of references on foreign trade will be a distinct aid to those business houses, banks, manufacturers and others who expect to participate in export business. The author, who is lecturer in commerce at the University of California, has gathered together only those sources which are recognized as authoritative, including publications of the Bureau of Foreign and Domestic Commerce and other Government papers. References are grouped under appropriate heads such as commercial policies and tariffs, directories, export journals, financing, foreign markets, geography and commerce, insurance, statistics, theory and international trade, transportation and trade routes and year books.

Personal

CAPTAIN EDWARD E. ASHLEY, JR., formerly consulting mechanical and electrical engineer for Starrett & Van Vleck, New York City, has resigned his commission in the Air Service of the U. S. Army, to accept the appointment as sales engineer of the Mercury Mfg. Co., Chicago, Ill.

DR. D. D. BEROLZHEIMER, librarian of the American Chemical Society, 1910 and 1911, librarian of the Chemists' Club, 1910 to 1915, and librarian of The Barrett Co., New York, since April, 1915, has severed his connection with the latter firm and is now assistant technical editor with the Chemical Catalog Co., 1 Madison Ave., New York City.

BRADLEY, BRUFF & LABARTHE have been retained by the Penarroya Mining & Metallurgical Co. of Paris to design a complete lead smelting and refining plant to be erected at Penarroya, Spain.

MAJOR F. E. BREITHUT, Chemical Warfare Service, has been detailed by the War Department to the War Trade Board to act as chairman of the chemical group of the price section. This group is engaged in a study of price fluctuation of chemicals during the war and an analysis of its cause and consequence. Associated with Major Breithut are Mr. F. W. Cassebeer, Capt. P. W. Carleton, Lieut. Chas. L. Fry, Lieut. W. N. Jones, Mr. H. L. Lewenberg, Capt. W. Lee Lewis, Mr. W. B. Meldrum, and Capt. H. L. Trumbull.

CAPT. DECOURCY BROWNE, Ordnance Department, U. S. A., expects to return to the United States from France in the near future and will be located at the Engineers' Club, 32

W. 40th Street, New York. Captain Browne, before entering the service, was metallurgical engineer of the Metal & Thermit Corporation, New York.

Col. G. A. Burrell, recently of the Chemical Warfare Service, has opened an office as consulting chemical engineer in Pittsburgh, Pa.

Mr. C. W. Cromwell of the engineering firm of A. G. McGregor, Warren, Ariz., is in New York City.

Mr Clarence T. Emrich resigned his position as chief chemist with the Old Dominion Co. to accept the position of assistant superintendent with the International Smelting Co. at Miami, Ariz.

Major A. C. Fieldner, Chemical Warfare Service, U. S. A., who was in charge of the gas mask research at the American University Experiment Station, Washington, D. C., has returned to the Pittsburgh station of the Bureau of Mines, where he will have charge of the chemical research laboratory.

Mr. Francis N. Flynn, manager of the Consolidated Mining and Smelting Co., Trail, B. C., has resigned to become assistant general superintendent of the Balbach Smelting and Refining Co., Newark, N. J.

Mr. Daniel Guggenheim has been succeeded as president of the American Smelting & Refining Co. and the American Smelters Securities Co. by his brother, Simon Guggenheim, formerly U. S. Senator from Colorado. Messrs. Murry Guggenheim and S. R. Guggenheim also retire from the active management of the companies.

Mr. F. H. Hawkins, who for several years past has held the position of chief assayer for the Standard-Silver Lead Mining Co. of Silverton, B. C., has gone to Anyox, B. C., to accept an appointment with the Granby Consolidated Mining & Smelting Co. Mr. Thomas Brown will succeed him at the Silverton assay office.

Mr. A. A. Heller, treasurer and general manager of the International Oxygen Co., has given up his active managerial duties. Mr. Eugene Schoen has been appointed general manager for the company. Mr. Heller, as treasurer, continues in charge of the financial departments of the business.

Mr. Frank J. Herman, formerly with W. J. Rainey and more recently manager of the coke section of the United States Fuel Administration, has resigned to accept a position as assistant to the president of the Rainey-Wood Coke Co., which is building a by-product coke plant at Swedeland, Pa.

Arthur D. Little, Inc., announces the following additions to its technical staff: Mr. Robert Woods Van Kirk, M. I. T. 1918, chemical engineer; recently engaged in the development division of the C. W. S., stationed at Cleveland, Ohio. Mr. John Stevens, M. I. T. 1918, chemical engineering administration; recently served as a private in the research division of the C. W. S., engaged upon gas defense work, stationed first at Washington and later in the Little laboratories. Lieut. Earl Place Stevenson, Wesleyan College, Middletown, Conn., 1916, B. S.; instructor in organic chemistry at M. I. T. 1917 and 1918; recently engaged in the research division, C. W. S., Washington and Boston. Mr. Eric R. Jette, Franklin and Marshall, Lancaster, Pa., 1918, B. S.; engaged as a civilian in the pyrotechnic section of the research division, C. W. S., Washington. In addition, the following members of the staff who had left the company's employ for governmental activities have returned to the staff: Mr. Harrison E. Howe, consulting chemist, Ordnance Department at large, assigned to the nitrate division, Army Ordnance, for the purpose of correlating the research being conducted in various laboratories on the fixation of atmosphere nitrogen, with which division appointment is still held. He is also commissioned Major, Ordnance Section, Officers Reserve Corps. Lieut. Roy C. Charron, who was first chemist for the division gas officer at Camp Devens, Mass., and later assistant to chief of the emergency laboratory section, polytechnic division, C. W. S., American University, Washington, D. C. Mr. J. M. Cullen, who was in the U. S. Navy.

Major George L. Norris, engaged in aircraft production, has received his honorable discharge from the Army and has returned to his former position as metallurgical engineer with the American Vanadium Co., Pittsburgh. Major Norris was district manager of production, Pittsburgh office, until Nov. 1, when he was transferred to Washington and assigned to duty as chief metallurgist, raw materials department, Bureau of Aircraft Production.

Mr. M. G. Spencer, formerly connected with the Midvale Steel Co. and later with the Watertown Arsenal, in the capacity of chief chemist, has joined the staff of the Electric Steel Co. of Indiana, Indianapolis, Ind., in charge of metallurgical operation.

Mr. E. E. Thum, Western editor of Chemical & Metallurgical Engineering, addressed the Utah Section of the A. I. M. E. Jan. 24, the subject being "Economic Situation of Certain War Minerals." Mr. Thum has also been asked to talk on the Nebraska potash industry before the Utah Society of Engineers, which is holding a symposium on potash on Feb. 19.

Mr. John T. Ward, who has been with the National Carbon Co., Inc., as chemical engineer at the Cleveland works, has been transferred to the New York office of the company as assistant to the works manager.

Mr. A. P. Watt, consulting engineer, of New York, has opened an office in Boston, where he will continue to specialize on ore concentration.

Mr. Henry Wigglesworth, of the National Aniline & Chemical Co., will take a leave of absence to serve for a time as a trade commissioner for the Bureau of Foreign and Domestic Commerce to study the dyestuff and textile conditions in France.

Obituary

Mr. Frank Baird, a graduate of the University of California, died recently at his home in Westwood Park, near San Francisco, following a brief illness from influenza and pneumonia. Mr. Baird was associated with his brother, Dudley Baird, in the Pacific Foundry Co., San Francisco. He is survived by his wife, to whom he was married last September, and by two brothers.

Lieut. Charles F. Hawkins died at the home of his parents on Dec. 27, 1918, of pneumonia following influenza. In August, 1917, he accepted a position as professor of chemistry at Williams College, resigning in February, 1918, to enlist with the Chemical Warfare Service. He was mustered out of the service Dec. 21 and returned to his home Dec. 23.

Mr. Ernest H. Simonds, metallurgical engineer, died at Oakland, Calif., Dec. 26, of influenza. Mr. Simonds was a graduate of the University of California and for a long time was instructor of assaying at that institution. Many of the California graduates will hear of his death with keen regret. After leaving the University of California, Mr. Simonds opened an assay office in San Francisco. The business was successfully established and was continued until the San Francisco earthquake and fire wiped it out. Simonds went next into metallurgical engineering, and established himself in a good practice.

Current Market Reports

The Non-Ferrous Metal Market

Saturday, Jan. 25.—The non-ferrous market is still lagging, while producers are reluctant to make sharp reductions enough to stimulate buying.

Aluminium:—The Government prices on ingots 98 to 99 per cent Al are $660 a ton f.o.b. plant in 50-ton lots; $662 down to 15-ton lots; and $666 down to 1-ton lots, which prices will continue until the first of March. Prices per pound for small lots vary from 40c. to 45c.; sheet aluminium, 18 ga. and heavier, 42c.; powdered aluminium, 100 mesh, 70c.

Antimony:—Wholesale lots of antimony are being offered at 7½c. while small lots bring from 7⅝c. to 7¾c. per lb.

Copper:—Prime lake is nominal at 23c. Electrolytic is selling at 20½c. and casting at 19c. The producers are determined to hold their prices high believing that the foreign demand will soon be strong.

Copper sheets, hot rolled	lb.	$0 29 —	$0.33
Copper sheets, cold rolled	lb.	.30 —	.34
Copper bottoms	lb.	37 —	.41
Copper rods	lb.	25¾	..
Copper wire	lb.	23	..
High brass wire	lb.	24½—	26¾
High brass sheets	lb.	24½—	26¾
High brass rods	lb.	23½—	25¾
Low brass wire	lb.	26½—	28¾
Low brass sheets	lb.	26½—	28¾
Low brass rods	lb.	27½—	29¾
Brazed brass tubing	lb.	35½—	37¾
Brazed bronze tubing	lb.	40½—	42¾
Seamless copper tubing	lb.	35 —	37
Seamless bronze tubing	lb.	40¾	.40¾
Seamless brass tubing	lb.	34 —	36
Bronze (gold) powder	lb.	1 00 —	1.75

Lead:— Great interest is evidenced in the action to be taken by the Senate on cancellation of war contracts, among which lead occupies a conspicuous place. Spot New York is quoted at 5.45c. to 5.5c. per lb. and St. Louis at 5c. to 5.2c.

Tin:—The U. S. Steel Products Co. has liquidated 3000 tons of the original 10,000-ton stock at the 72c. basis. It is expected that it will take several months to dispose of the remaining stock, after which prices will fall sharply.

Zinc:—Spelter continues its gradual decline, with spot New York at $144 to $145 per ton; East St. Louis, spot $138, Jan. $137, Feb. $136, March $135 and April $134.

OTHER METALS

Bismuth	lb.	$3 50 —	$3 65
Cadmium	lb.	1 50 —	
Cobalt	lb.	2 50 —	3 50
Magnesium	lb.	1 75 —	2 10
Mercury	75 lb.	105 00 —	
Mercury	lb.	1 95 —	
Nickel	lb.	.40 —	45
Tungsten	lb.	34 00 —	
Iridium	oz.	175 00 —	
Palladium	oz.	135 00 —	
Platinum	oz.	105 00 —	108 00
Silver	oz.	1 01½—	

The Iron and Steel Market

The rate of production on both pig iron and steel continues to decline, being in steel ingots and castings perhaps 60 per cent of capacity at the close of January, as against 80 per cent at the beginning of the month, and about 90 per cent during each of the last four months of 1918. The rate may easily, from present indications, fall below 50 per cent before the end of February. Pig iron production has not declined as much as steel production, and for this divergence various reasons may be assigned. There is a fair consumption of pig iron by foundries, and indeed some foundries, whose operation was greatly curtailed during the war, are more active. Steel works are under contract for pig iron and not for scrap, and on that account may be using a higher percentage of pig iron and a lower percentage of scrap, although the cheaper production would be by using more scrap, as scrap has declined greatly in price and pig iron is down only $3.

From a general survey of the situation the astonishing thing is not that steel production is so light, but that it is so heavy. There appears to be scarcely any demand for steel, and yet a 50 per cent operation of the present capacity means 1,500,000 gross tons per month of finished rolled steel. The Fleet Corporation is mentioned as the largest steel consumer, but during its period of greatest pressure for steel it was calling for only about 250,000 gross tons a month, and it then accumulated a surplus which it now desires to reduce. Next, the automobile industry is spoken of as a good customer of the steel industry, but it would do well to consume 100,000 tons of steel a month. As to the railroads, they are taking scarcely any rails or structural steel, but there is a very fair rate of locomotive production, and about 75,000 freight cars of the 100,000 ordered by the Railroad Administration last April are still to be delivered and the manufacture of those cars is proceeding at a good rate.

Roughly speaking, about one-third of the present steel production is against new orders booked from week to week and about two-thirds is against old orders, which, of course, are gradually playing out. The new orders are increasing slowly, not as rapidly in point of tonnage as old orders are completed, and thus the trend in production is downward. A distinct improvement in demand is expected with early spring and it depends upon how far the decline in production has gone by then whether the increase in new business will be sufficient to arrest the decline and produce an increase in operations.

Prices

Prices of pig iron, unfinished steel and finished steel are being held rigidly. There can hardly be any question about this, as all producers are watching the market situation very closely, and evidently with the intention of meeting price cutting if it occurs. No mill intends to permit another mill to "get away" with a "gumshoe campaign" such as have sometimes been conducted in the past in somewhat similar circumstances. The theory once entertained in many quarters that it would be possible for demand for iron and steel to revive with the present price level maintained is now almost everywhere abandoned. Views of the general economic situation from all angles are that there must be a general reconstitution of commodity and labor values. Commodity prices cannot stay up because labor costs are high, and labor costs cannot stay up because commodity prices are high. They did not help keep each other down during the war, and they are powerless to keep each other up in future. New construction and development are essential to industrial activity and prosperity, and the new things to be created could not compete with those in existence. While the cost of both commodities and labor has greatly increased, the intrinsic value of the material wealth of the country has not been similarly marked up, and in the long run it will exercise an important controlling influence. In the iron and steel industry proper there is no prospect that wage rates will experience any great decline in the near future, not for six months or more, but there will be an increase in labor performance, whereby labor cost will be reduced. In the activities that normally are the great steel consumers, particularly building and construction work of all sorts, a great decrease in labor costs is to be expected, through better labor performance, through the disappearance of premium rates and bonuses, and perhaps through some declines in actual wage rates.

Steel Contracts

After giving more or less favorable consideration to the new form of steel sales contract for several weeks, the directors of the American Iron & Steel Institute voted on Jan. 24 not to recommend any contract for adoption by the steel mills, and to discharge the contract committee that had been in existence for several years. The proposed contract form was drawn up with the object of making contracts binding in the finished steel trade and eliminating the practice of considering them options given by the producer to the buyer. Its important features was two paragraphs providing for the payment of "liquidated damages" by the mill if it failed to ship on time or by the buyer if he failed to specify on time. The object, of course, was not to make it that there would be large payments of this sort, but to make it that contract engagements would be so made that they could be lived up to. Those who advocated the new contract pointed out how "unbusinesslike" is the customary method of doing business, and how different it is from practices in other industries. Apparently they did not attach much importance to the fact that under the practices complained of the steel industry has been very successful, with practically no failures and with good profits except in periods of depression when such contracts did not exist.

The Next Active Period

The belief continues that there is in store for the iron and steel industry a period of several years of great activity and prosperity, the chief question being when that period will begin. There can, of course, be a full demand for the tonnage of steel that can now be made, 40 per cent greater than the capacity existing in 1914, only when there is great activity in new construction of all sorts. Construction costs must come down and the prospective investor must otherwise be assured that his investment will prove profit-

able. The only thing clear is that such a condition does not exist at present. It seems fair to assume that the peace settlement must be completed, the menace of bolshevism removed and the future status of the railroads determined.

Chemical Market

COAL TAR PRODUCTS:—Many of the operators in coal tar products regard the period of uncertainty now prevailing but temporary, although predictions vary when business will again open up and there are those who are not disposed to take an aggressive stand one way or the other. On the other hand, however, it is generally conceded that the coal tar industry has developed to such enormous proportions that the growth will result in a reduction of cost in production, which will mean lower prices to the consumer, therefore bringing about a more favorable market for American products under the heading and it appears to be the consensus that prospects for the near future are bright. In the meantime the general tone of the market is quiet, with most of the crude products but phenol and toluol holding firm in price, although the latter item has maintained a more steady position in the market at the recent decline.

Xylol: — The result of the Government's release of this item has been felt in the market, the spot situation being much easier, while the consuming demand is fairly steady and prices are firmly maintained.

Aniline Oil: — Most producers have now reduced their prices to the level of other manufacturers of this product, but there continues to be a lack of interest generally displayed about the market, with trading in small lots being the only movement noted.

Paranitraniline: — The lack of demand combined with keener competition has brought about a lower market for this product, offerings of which attract no important buying interest, despite the price concessions generally made, particularly by weak holders in the resale market.

Paraphenylenediamine: — The item is one of the coal tar products that has maintained a rather firm position in the market and most factors in this line report a fair volume of business passing. Quotations in the general market would indicate no important price changes.

H Acid: — Available supplies of this product are more than sufficient to meet the current call and a decline in price has been general throughout the market.

Sulphanilic Acid: — Many users of this material have their own facilities for production. However, beyond this situation there has been no pressing demand on the part of consumers, but on the contrary, trading has been very quiet and prices in most instances were subject to a decline.

Mixed Toluidine: — This market remains without special feature. Quiet trading is generally in evidence and prices have also been reduced 10c. to 15c.

Naphthaline: — A fair resumption of buying interest has taken place for this product and the market remains steady with prices quotably unchanged.

Phenol :— There has been no indication of any return to more normal trading for this crude, which is subject to a very unsettled position, with resale offerings being made in liberal quantities at such prices that the actual producers, who are striving to maintain at least a fair market, are apparently unable to create any buying interest.

Benzol: — There is a fair volume of business passing for this product, but trading is not in such important quantities to effect stocks on hand, which are available in liberal lots. Material in tank cars and the prices asked for that in drums remain at the previous levels.

Metaphenylenediamine: — While offerings of this material on the spot are none too liberal, there is little demand on the part of consumers and no difficulty is experienced in meeting the current call. The recent price concessions have seemingly originated no important interest on the part of buyers.

Orthotoluidine: — The item was sharply reduced in price, due to keener competition and the lack of demand, but prices apparently do not figure, from a buyer's viewpoint, as consumers have not changed from their disposition in buying only for their immediate needs.

HEAVY CHEMICALS:—There has been a continued lack of buying interest in most all the items under this heading. The marine strike, which did not reach a climax, it was feared would be a considerable handicap, but the trouble had a sudden end and the favorable reaction anticipated has not developed in any important volume, although export trading has shown signs of life. Declines in prices have been quite evident but not general, and it is unlikely that there will be any continuation of downward prices to the levels of pre-war trading. The spot market is seemingly controlled by second hands, with the actual producers not disposed to meet these lower prices. They claim that, up to the present, conditions have not been such to compel meeting this competition, the result being producers' figures are generally the outside.

Soda Ash: — A weak and unsettled market is quite evident for this material, with single bags sold during the week as low as $1.40 per hundred pounds. Bags from the warehouse were available at this figure up to the close with prices on a parity in Philadelphia, and in Chicago $1.65 was asked. Barrels ex-warehouse were quoted at $1.85 per hundred pounds, while double bags in the Middle West were held at $2.15 to $2.25 per hundred pounds.

Caustic Soda: — A more favorable inquiry was noted for the 76 per cent solid, but trading has not been in any appreciable quantities and sales were consummated at 3c. ex-store-New York and $3.20 to $3.25 f.a.s. The undertone of the market, however, appeared to be steadier and resale lots were quoted at from $3.15 to $3.20 per hundred pounds, ex-warehouse and $3.25 to $3.35 f.a.s. Producers generally quote future shipments at 3¼c. per pound, basis 60 per cent. Ground caustic is generally quoted at $4.10 to $4.35 per hundred pounds, but sales are only in occasional small lots.

Bleaching Powder: — Export drum material appears to have been the only item that was subject to any important call, with sales passing at 3c. f.a.s. The product in domestic drums was subject to no particular call and offerings from the warehouse were made at $1.90 per hundred pounds, while export drums at Niagara were quoted at 2½c.

Copper Sulphate: — A rather brisk business for export purposes, particularly to north Europe and Greece, is passing, while local trading is rather quiet. Standard 99 per cent plus large crystals are offered at 8¾c. per pound in large quantities and small crystals, 98½ per cent test, are offered at 8¼c. per pound in carload lots.

Formaldehyde: — Resale lots reached the market at prices ranging from 22c. to 22½c. per pound and sales were reported to be passing at this figure. There is no liberal supply on hand and producers offer no encouragement for the immediate future, but are offering late February shipments at 23c. per pound.

Chlorate of Potash: — Operators in this commodity experienced a fair trading for export purposes and contracts in appreciable quantities have been placed with the domestic trade. Quotations remain firm at 40c. per pound ex-store and f.a.s.

Bichromate of Potash: — Forward shipments are offered at 37c. per pound through second hands, while producers are now offering spot material at the same price, and for large orders this price can be done f.a.s.

Caustic Potash: — Sales have been consummated for 88 to 92 per cent in the resale market as low as 52c. There is a lack of demand in evidence, which has seemingly brought about a lower market for this product, despite the fact that some large manufacturers have been striving to maintain prices, and as high as 67c. is being asked. There were offerings from a western source at 58c. per pound for the 88 to 92 although as low as 55c. was quoted for large quantities.

Cream of Tartar: — The item continues to be neglected to a very noticeable extent and offerings of the product are now made at 60½c. to 61½c. in barrels and 62½c. to 63c. in kegs ex-warehouse.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET JAN. 10, 1919

Acetic anhydride	lb.	1.00 —	1.25
Acetone	lb.	.25½ —	.25½
Acid, acetic, 28 per cent	cwt.	3.50 —	3.75
Acetic, 56 per cent	cwt.	7.00 —	7.50
Acetic, glacial, 99½ per cent, carboys	cwt.	14.50 —	15.00
Boric, crystals	lb.	.13½ —	.15
Citric, crystals	lb.	1.25 —	1.27
Hydrochloric, C. P	lb.	Nominal	
Hydrofluoric, 30 per cent, in barrels	lb.	.08 —	.08½
Lactic, 44 per cent	lb.	.14 —	.15
Lactic, 22 per cent	lb.	.06 —	.07
Molybdic, C. P	lb.	6.90 —	7.40
Nitric, 36 deg	lb.	Nominal	
Nitric, 42 deg	lb.	08½ —	.10
Oxalic, crystals	lb.	.36 —	.38
Phosphoric, 47-50 per cent paste	lb.	.07½ —	.10
Phosphoric, ref. 50 per cent	lb.	.35 —	.40
Picric	lb.	.75 —	.85
Pyrogallic, resublimed	lb.	3.25 —	3.50
Sulphuric, 60 deg works	ton	14.00 —	16.00
Sulphuric, 66 deg works	ton	26.00 —	...
Sulphuric, oleum (Fuming), tank cars	ton	60.00 —	65.00
Tannic, U. S. P., bulk	lb.	1.40 —	1.50
Tartaric, crystals	lb.	.85 —	.87
Tungstic, per lb. of W	lb.	1 70 —	1.75
Alcohol, sugar cane, 188 proof	gal.	4 85 —	...
Alcohol, wood, 95 per cent	gal.	1.20 —	1.22
Alcohol, denatured, 180 proof	gal.	.56 —	.60
Alum, ammonia lump	lb.	.05½ —	.06
Alum, chrome ammonium	lb.	.17½ —	.18
Alum, chrome potassium	lb.	.20 —	.22
Alum, chrome sodium	lb.	.12½ —	.13
Alum, potash lump	lb.	.09½ —	.10
Aluminium sulphate, technical	lb.	.02½ —	.02½
Aluminium sulphate, iron free	lb.	.03½ —	.03¾
Ammonia aqua, 26 deg., carboys	lb.	.07 —	.08½
Ammonia, anhydrous	lb.	.40 —	.45
Ammonium carbonate	lb.	.13 —	.14
Ammonium nitrate	lb.	.16 —	.17
Ammonium, sulphate domestic	lb.	.06 —	.07
Amyl acetate	gal.	3.75 —	4.25
Arsenic, white	lb.	.10 —	.11
Arsenic, red	lb.	.65 —	.70
Barium carbonate, 99 per cent	ton	80.00 —	90.00
Barium carbonate, 97-98 per cent	ton	65 00 —	67.00
Barium chloride	ton	65.00 —	75.00
Barium sulphate (Blanc Fixe, Dry)	lb.	.04½ —	.05
Barium nitrate	lb.	.10 —	.11
Barium peroxide, basis 70 per cent	lb.	.30 —	.32
Bleaching powder, 35 per cent chlorine	lb.	.02 —	.03½
Borax, crystals, sacks	lb.	.08¼ —	.08½
Brimstone, crude	ton	65.00 —	70.00
Bromine, technical	lb.	.65 —	...
Calcium, acetate, crude	lb.	.04 —	.05
Calcium, carbide	lb.	.10½ —	.11½
Calcium chloride, 7-75 per cent, fused, lump	ton	22.00 —	24.00
Calcium peroxide	lb.	1.50 —	1.70
Calcium phosphate	lb.	.22 —	.23
Calcium sulphate, 98-99 per cent	lb.	.09 —	.09½
Carbon bisulphide	lb.	.08 —	.09
Carbon tetrachloride, drums	lb.	.15 —	.16
Carbonyl chloride (phosgene)	lb.	.75 —	1.00
Caustic potash, 88-92 per cent	lb.	.62 —	.65
Caustic soda, 76 per cent	100 lb.	3.15 —	3.25
Chlorine, liquid	lb.	.10 —	.12
Cobalt oxide	lb.	1 60 —	1.65
Copperas	lb.	.01½ —	.02½
Copper carbonate	lb.	.30 —	.31
Copper cyanide	lb.	75 —	.78
Copper sulphate, 99 per cent, large crystals	lb.	08½ —	.08½
Cream of tartar, crystals	lb.	.60½ —	.65
Epsom salt, bags, U.S.P.	100 lb.	2 75 —	...
Formaldehyde, 40 per cent	lb.	.21½ —	.22
Glauber's salt	lb.	.02 —	.02½
Glycerine, bulk, C.P.	lb.	.20 —	.21
Iodine, resublimed	lb.	4 25 —	4 30
Iron oxide	lb.	.06 —	.08
Lead acetate, white crystal	lb.	.17 —	.17
Lead arsenate (Paste)	lb.	.15 —	.18
Lead nitrate, C. P	lb.	.85 —	.86
Litharge, American	lb.	.11 —	.12
Lithium, carbonate	lb.	1 50 —	2.05
Magnesium carbonate, technical	lb.	.16 —	.17
Nickel salt, single	lb.	.14 —	.15
Nickel salt, double	lb.	.12 —	.13
Phosgene (see Carbonyl chloride)	lb.	.75 —	1.00
Phosphorus, red	lb.	.90 —	.95
Phosphorus, yellow	lb.	.75 —	.80
Potassium bichromate	lb.	.38 —	.40
Potassium bromide granular	lb.	1 25 —	1.26
Potassium carbonate calcined, 85-90 per cent	lb.	.38 —	.40
Potassium chlorate, crystals	lb.	.38 —	.40
Potassium cyanide, 98-99 per cent	lb.	.60 —	.70
Potassium iodide	ton	3.75 —	3.80
Potassium muriate, 80-85 p. c. basis of 80 p. c.	lb.	300 00 —	350 00
Potassium nitrate	lb.	.27 —	.31
Potassium permanganate, U. S. P.	lb.	1 10 —	1.20
Potassium prussiate, red	lb.	2 30 —	2 50
Potassium prussiate, yellow	lb.	65 —	.75
Potassium sulphate, 90-95 p. c. basis 90 p.c.	ton	Nominal	
Rochelle salts	lb.	46½ —	.48
Salammoniac, gray gran	lb.	.16 —	.18
Salammoniac, white gran	lb.	.14 —	.16
Salsoda	100 lb.	1 15 —	1.20
Salt cake	ton	18 00 —	20 00
Silver cyanide, based on market price of silver	oz.	...	...
Silver nitrate	oz.	63½ —	.64
Soda ash, 58 per cent, light, flat (bags)	100 lb.	1 75 —	1.95
Soda ash, 58 per cent, dense, flat	100 lb.	3 35 —	3.50
Sodium acetate	lb.	.15 —	.18
Sodium bicarbonate, domestic	lb.	02½ —	.03
Sodium bicarbonate, English	lb.	...	...
Sodium bichromate	lb.	.17½ —	.18½
Sodium bisulphite, powd	lb.	.12 —	.14
Sodium chlorate	lb.	.18 —	.20
Sodium cyanide	lb.	.30 —	.35
Sodium fluoride, commercial	lb.	.16 —	.17
Sodium hyposulphite	lb.	3 10 —	3.50
Sodium molybdate, per lb. of Mo	lb.	2.50 —	...
Sodium nitrate, 95 per cent	100 lb.	4.42 —	4.55
Sodium nitrite	lb.	.19 —	.20
Sodium peroxide	lb.	.35 —	.45
Sodium phosphate	lb.	.04 —	.04½
Sodium prussiate, yellow	lb.	.30 —	.32
Sodium silicate, liquid (60 deg.)	lb.	.05 —	.06
Sodium sulphide, 30 per cent, crystals	lb.	.02 —	.03
Sodium sulphide, 60 per cent, fused	100 lb.	.05 —	.06
Sodium sulphite	lb.	.05½ —	.06
Strontium nitrate	lb.	.25 —	.30
Sulphur chloride, drums	lb.	.07½ —	.09
Sulphur dioxide, liquid, in cylinders	lb.	.15 —	.40
Sulphur, flowers, sublimed	100 lb.	4 35 —	4 50
Sulphur, flowers, sublimed	100 lb.	3.70 —	3.85
Sulphur, roll	ton	65.00 —	70 00
Sulphur, crude	ton	.28 —	.29
Tin bichloride, 50 deg	lb.	.75 —	.76
Tin oxide	lb.	.18 —	.20
Zinc carbonate	lb.	.15 —	.15½
Zinc chloride	lb.	Nominal	
Zinc cyanide	lb.	.13¼ —	.14
Zinc dust, 350 mesh	lb.	.10 —	.12
Zinc oxide, American process XX	lb.	.04¼ —	.06½
Zinc sulphate	lb.	...	...

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.22 —	.27
Benzol, 90 per cent	gal.	.25 —	...
Toluol, in tank cars	gal.	.25 —	...
Toluol, in drums	gal.	.30 —	.35
Xylol, pure, water white	gal.	.45 —	.55
Solvent naphtha, water white	gal.	.20 —	.25
Solvent naphtha, crude, heavy	gal.	.15 —	.17
Creosote oil, 25 per cent	gal.	.45 —	.55
Dip oil, 20 per cent	gal.	.35 —	.40
Pitch, various grades	ton	8.00 —	20 00
Carbolic acid, crude, 95-97 per cent	lb.	Nominal	
Carbolic acid, crude, 50 per cent	lb.	Nominal	
Carbolic acid, crude, 25 per cent	lb.	Nominal	
Cresol, U. S. P.	lb.	.18 —	20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00 —	1.10
Alpha naphthol, refined	lb.	1.50 —	1.60
Alpha naphthylamine	lb.	.50 —	.55
Aniline oil, drums extra	lb.	.26 —	.30
Aniline salts	lb.	.36 —	.40
Anthracene, 80 per cent	lb.	.50 —	.55
Benzaldehyde (f.f.c.)	lb.	4.25 —	4.50
Benzidine, base	lb.	1.45 —	1.60
Benzidine, sulphate	lb.	1.15 —	1.25
Benzoic acid, U. S. P.	lb.	1.80 —	1.90
Benzoate of soda, U. S. P	lb.	1.65 —	1.70
Benzyl chloride	lb.	1.00 —	...
Beta naphthol benzoate	lb.	10.00 —	12.00
Beta naphthol, sublimed	lb.	.75 —	.85
Beta naphthylamine, sublimed	lb.	2.60 —	2.65
Dichlorbenzol	lb.	.15 —	.20
Diethylaniline	lb.	3.25 —	4.00
Dinitrobenzol	lb.	.36 —	.38
Dinitrochlorbenzol	lb.	.35 —	...
Dinitronaphthaline	lb.	.55 —	.60
Dinitrotoluol	lb.	.40 —	.50
Dinitrophenol	lb.	.49 —	.50
Dimethylaniline	lb.	.57 —	.65
Diphenylamine	lb.	1.00 —	1 10
H-acid	lb.	2 35 —	2.75
Metaphenylenediamine	lb.	1.55 —	1.75
Monochlorbenzol	lb.	.16 —	.19
Naphthalene, flake	lb.	.09 —	...
Naphthalene, balls	lb.	.12 —	.12½
Naphthionic acid, crude	lb.	1 20 —	1.30
Naphthylamin-di-sulphonic acid	lb.	1 00 —	1.10
Nitro naphthaline	lb.	.45 —	.50
Nitro toluol	lb.	.55 —	.60
Ortho-amidophenol	lb.	6.00 —	7.00
Ortho-dichlor-benzol	lb.	.15 —	.20
Orthotoluidine	lb.	.50 —	.90
Ortho-nitro-toluol	lb.	.75 —	.85
Para-amidophenol, base	lb.	3.75 —	4.25
Para-amidophenol, H. C. L	lb.	3.75 —	4.25
Para-dichlor-benzol	lb.	.15 —	.20
Paranitraniline	lb.	1.40 —	1.60
Para-nitro-toluol	lb.	1.50 —	1.60
Paraphenylenediamine	lb.	3.25 —	3.50
Para toluidine	lb.	2.25 —	2.50
Phtbalic acid anhydride	lb.	3.25 —	3 50
Phenol, U. S. P	lb.	Nominal	
Resorcin, technical	lb.	4 50 —	5.00
Resorcin, pure	lb.	7.00 —	8.00
Salicylic acid, U. S. P	lb.	.65 —	.75
Salol	lb.	1 50 —	2.00
Sulphanilic acid, crude	lb.	.25 —	.31
Toluidine	lb.	2.50 —	3.00
Toluidine-mixture	lb.	.80 —	1.00

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	4 00 —	...
Corning, Ohio	bbl.	2 85 —	...
Somerset, Ky	bbl.	2.60 —	...
Wooster, Ohio	bbl.	2.58 —	...
Indiana	bbl.	2 28 —	...
Illinois	bbl.	2.25 —	...
Oklahoma and Kansas	bbl.	2.25 —	...
Caddo, La., light	bbl.	2.10 —	2.25
Corsicana, Tex., light	bbl.	2.25 —	...
California	bbl.	1.24 —	1.57
Gulf Coast	bbl.	1.35 —	...
Mexican	bbl.	1 90 —	...
Fuel Oil			
New York	gal.	.15 —	...
Philadelphia	gal.	.10½ —	...
Baltimore	gal.	.07½ —	.15
Pittsburgh	gal.	.07½ —	.10½
Texas	bbl.	1.85 —	2.35
Los Angeles	bbl.	1.65 —	...

Gasoline (Wholesale)

New York, motor	gal.	.24½	—	....
Gas machine	gal.	.41½	—	....
72-76 degrees	gal.	.33½	—	.39½
70-72 degrees	gal.	.32	—	.37½
67-70 degrees	gal.	.30½	—	.36½
Pittsburgh, motor	gal.	.25½	—	....
Chicago, motor	gal.	.21	—	....
Oklahoma, motor	gal.	.23½	—	....
San Francisco, motor	gal.	.20½	—	....

Paraffine Waxes

Crude, 103 to 105 deg. m.pt	lb.	.08½	—	.09
Crude, 118 to 120 deg. m.pt	lb.	.09½	—	.10
Crude, 124 to 126 deg. m.pt	lb.	.10	—	....
Refined, 120 deg. m.pt	lb.	.13½	—	....
Refined, 128 deg. m.pt	lb.	.14	—	....
Refined, 135 deg. m.pt	lb.	.16	—	.16½
Ozokerite, brown	lb.	.75	—	.80
Ozokerite, green	lb.	.85	—	.90

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.24	—	.25
Cylinder, light	gal.	.42	—	.44
Cylinder, dark	gal.	.39	—	.43
Paraffine, high viscosity	gal.	.40	—	.41
Paraffine, 0.903 sp. gr.	gal.	.36	—	.38
Paraffine, 0 885 sp. gr.	gal.	.26	—	.28

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f. o. b. Florida	gal.	.44	—	....
Pine oil, steam-distilled, sp. gr. 0.925-0.940	gal.	.58	—	.60
Pine oil, destructively distilled	gal.	.58	—	.60
Pine-tar oil, sp. gr. 1.02-1.035	gal.	.35	—	....
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal	.42	—	....
Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f.o.b. works	gal.	.37	—	....
Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.28	—	....
Pine-tar oil, ref., thin, sp. gr. 1.060-1.080	gal.	.32	—	....
Turpentine, crude, sp. gr. 0.870-0.900	gal.	.45	—	....
Hardwood oil, f.o.b. Michigan, sp.gr. 0.960-0.990	gal.	.23	—	....
Hardwood oil, f.o.b. Michigan, sp.gr. 1.06-1.08	gal.	.23	—	....
Wood creosote, ref., f.o.b. Florida	gal.	.31	—	....

Naval Stores

Rosin A-E barrel	280 lb.	14 00	—	14 20
Rosin F-I	280 lb.	14 20	—	14 75
Rosin K-N	280 lb.	16 70	—	17 25
Rosin WG-W	280 lb.	17 75	—	....
Spirits of turpentine	gal.	.74	—	.75
Wood turpentine, steam distilled	gal.	.68	—	.69
Wood turnpentine, destructively distilled	gal.	.63	—	.65½
Pitch	bbl. 200 lb.	8 00	—	....
Tar, kiln dried	280 lb.	13 00	—	13 50
Retort tar	280 lb.	14 00	—	14 50
Rosin oil, first run	gal.	.77	—	....
Second run	gal.	.80	—	....
Third run	gal.	.85	—	....
Fourth run	gal.	.95	—	....

Vegetable Oils

Castor oil	lb.	.25	—	.26
China wood oil	lb.	.23	—	.24
Cocoanut oil	lb.	.16	—	.21
Corn oil	lb.	.18	—	....
Cottonseed oil, crude	lb.	.17½	—	.22
Linseed oil, raw, cars	gal.	1.45	—	1 48
Palm	lb.	.18	—	.21½
Peanut oil, crude	lb.	.17½	—	.21
Soya bean oil, Manchuria	lb.	.14	—	.15

Glues

Extra white	lb.	.31	—	.35
Cabinet	lb.	.25	—	.26
Brown foot stock	lb.	.15	—	.19
Fish glue, 50-gal. barrels	gal.	1 00	—	1 50

Miscellaneous Materials

Barytes, floated, white, foreign	ton	Nominal		
Barytes, floated, white, domestic	ton	33.00	—	36.00
Beeswax, white, pure	lb.	.63	—	.65
Beeswax, unbleached	lb.	.43	—	.48
Blanc fixe	lb.	.05½	—	....
Casein	lb.	.17½	—	.30
Ceylon graphite	lb.	.07½	—	.25
Chalk, light, precipitated, English	lb.	.04½	—	.06
China clay, imported, lump	ton	20.00	—	40.00
China clay, domestic, lump	ton	15.00	—	22.50
Feldspar	ton	8.00	—	12 00
Fluorspar, gravel, f. o. b. mines	ton	28.00	—	40.00
Fluorspar, washed, powdered	ton	90.00	—	....
Fuller's earth, powdered	100 lb.	1.50	—	2 00
Japan wax	lb.	.26	—	.27
Mexican graphite	ton	60.00	—	75.00
Madsgascar graphite	lb.	.10	—	.15
Orange shellac	lb.	.72	—	.80
Pumice stone	lb.	.04	—	.08
Red lead, dry, carloads	100 lb.	.11½	—	.11½
Soapstone	ton	15.00	—	25.00
Stearic acid, 120 deg. m.pt	lb.	.13	—	.14
Stearic acid, 140 deg. m.pt	lb.	.18	—	.19
Talc, American, white	ton	20.00	—	40.00
White lead, dry	lb.	.14	—	.14½

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	175.00	—	....
Chrome cement	net ton	75 00	—	....
Clay brick, first quality fireclay	per 1000	50.00	—	55.00
Clay brick, second quality	per 1000	35 00	—	40 00
Magnesite, raw	ton	30.00	—	35 00
Magnesite, calcined, powdered	ton	50.00	—	65.00
Magnesite, dead burned	net ton	50 00	—	60 00
Magnesia brick, 9x4½x2½	net ton	110 00	—	125 00
Silica brick	per 1000	50 00	—	60 00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent, carloads, f. o. b. Niagara Falls, N. Y	ton	200.00	—	250 00
Ferrocerium	lb.	15.00	—	30 00
Ferrochromium, per lb. of Cr	lb.	.30	—	.40
Ferromanganese, domestic, 70 per cent basis	ton	150.00	—	200 00
Ferromanganese, English	ton	....	—	....
Spielgeleisen (16-18%)	ton	60.00	—	....
Ferromolybdenum, per lb. of Mo	lb.	3.50	—	4.50
Ferrosilicon, 75 per cent, f. o. b. N. Y	ton	....	—	....
Ferrosilicon, 50 per cent, contract	ton	125.00	—	....
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	Nominal		
Ferrouranium, f.o.b. works, per lb. of U	lb.	7.50	—	....
Ferrovanadium, f.o.b. works	lb.	....	—	....

Ores and Semi-finished Products

Chrome ore, 45 per cent minimum, fo.b Cal. per unit	ton	1.50	—	1.55
Coke	ton	6 00	—	7.00
Petroleum Coke	ton	16.00	—	....
Manganese ore, 48 per cent and over, per unit	ton	1 20	—	....
Manganese ore, chemical	ton	80 00	—	100 00
Molybdenite, per lb. of MoS_2	lb.	1 25	—	1 50
Tungsten, Scheelite, per unit of WO_3	ton	17.00	—	24 00
Tungsten, Wolframite, per unit of WO_3	ton	15.00	—	21 00
Uranium oxide, 96%	lb.	3.25	—	3.60
Vanadium pentoxide, 99%	lb.	10.50	—	....
Pyrites, foreign	unit	17	—	....
Pyrites, domestic	unit	28	—	.30½

Plant Supplies

BUILDING MATERIALS

Common clay bricks	M	14 00	—	15.00
Faced Brick	M	37.00	—	46.00
Hollow tile, 4x12x12	M	60 00	—	....
Hollow tile, 12x12x12	M	170.00	—	....
Lime	ton	16 50	—	....
Portland cement	bbl.	2.59	—	....
Single glass (82-lb.), 10x26-16x24		21 00	—	27.00
Double glass (164 lb.), 10x26-16x29		31.00	—	39 00
Yellow pine lumber	M	39 00	—	45.00
Cypress	M	70.00	—	....
Tarred felt (14-lb. sq.)	ton	68 00	—	....
Roofing pitch	ton	27.00	—	....
Asphalt coated roofing (35-55-lb.sq.)	sq.	1 60	—	2.45
Slate surfaced asphalt shingles	sq.	5.25	—	5.50
Corrugated galvanized iron	ton	109.00	—	127.00
Putty	100 lb.	6 25	—	....
Red oxide (Ppte. Copperas)	100 lb.	15 00	—	20 00
Native red oxide	100 lb.	3.25	—	8 00
Red metallic paint	100 lb.	1.20	—	1.50
White lead in oil	100 lb.	15 00	—	16.00
Red lead in oil	100 lb.	12.28	—	14 50
Zinc oxide (dry)	100 lb.	13 00	—	14.50
Zinc oxide—leaded	100 lb.	9 00	—	10.00
Yellow ochre	100 lb.	1 50	—	10.00
Ultra marine blue	100 lb.	14 00	—	50.00
Prussian blue	100 lb.	135.00	—	150 00
Chrome green	100 lb.	40 00	—	70 00
Paris green	100 lb.	43.00	—	49 00
Mineral black	100 lb.	1.75	—	2.25
Powdered bone black	100 lb.	5 50	—	12.00
Lampblack	100 lb.	15 00	—	45.00
Gas carbon	100 lb.	16.00	—	25 00
Mexican petroleum pitch	100 lb.	1.00	—	2 00
Gilsonite	100 lb.	2.00	—	2 50
Coal tar pitch	100 lb.	60	—	1.25

STRUCTURAL IRON

Blue annealed sheet iron	ton	77 00	—	82.00
Black sheet iron	ton	90.00	—	96.00
Galvanized iron	ton	101 00	—	131.00
Tern plate, 8-lb. coating	ton	145.00	—	148.00
Tern plate, 15-lb. coating	ton	175.00	—	....
Tern plate, 25-lb. coating	ton	200.00	—	....
Tern plate, 40-lb. coating	ton	230 00	—	....
Tin plate, prime	ton	147 00	—	155.00
Tank plates	ton	60.00	—	65.00
Beams, channels, angles, T's, Z's	ton	56 00	—	60.00
Rivets	ton	88 00	—	92.00
Steel pipe, ⅜ to 3-inch	ton	51 00	—	....
Bar iron and steel	ton	60.00	—	70.00
Chain (1 inch proof coil)	ton	150 00	—	....
Nails, bolts, nuts, washers	ton	70.00	—	80.00
Tool steel, special alloys	ton	300.00	—	500.00
Bessemer pig iron	ton	32.00	—	35.20
Bessemer steel	ton	43.50	—	47.50
No. 2 foundry	ton	37.90	—	....
Steel billets (4 x 4)	ton	47 50	—	....

POWER HOUSE SUPPLIES

Steam packing, rubber duck	lb.	99	—	1.10
Asbestos, high pressure	lb.	1.76	—	....
Asbestos, wired	lb.	1.30	—	....
Asbestos, graphited braid	lb.	1.21	—	....
Asbestos, wick	lb.	.75	—	....
Rubber, sheet	lb.	.66	—	....
Cup grease	lb.	.07	—	....
Transmission grease	lb.	07	—	....
Axle grease	lb.	.04½	—	....
Gear grease	lb.	.04½	—	....
Cotton waste	lb.	.08½	—	.11
Hose, underwriters, 2½ in	ft.	75	—	....
Hose, air, ¾ in	ft.	50	—	.60

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Arizona

GLOBE.—The city has awarded the contract for the construction of a sanitary sewerage system and sewage disposal plant, to include two Imhoff tanks, two sludge beds, one chlorinator house, etc., to the Clark & Henery Construction Co., Stockton, Calif. Estimated cost, $226,530. Noted Nov. 30.

PHOENIX.—The United Verde Extension Mining Co. has awarded the contract for constructing various buildings at its mine here, to Paul Michelson, Phoenix, percentage basis. About $500,000 will be expended.

Colorado

BOULDER.—The Colorado Pitchblend Co. will build a concentration mill at its mine at Jamestown and is in the market for milling equipment and lumber. Estimated cost, $300,000. J. F. Barnhill, manager.

TELLURIDE.—The Tomboy Gold Mines Co., Ltd., will build a new mill at its mine at Savage Basin and is in the market for oil flotation equipment. Estimated cost, $150,000. D. A. Herron, manager.

Connecticut

BRIDGEPORT.—The Bridgeport Hospital, Grant St., will build a pathological laboratory on Mill Hill Ave. Estimated cost, $50,000.

Illinois

ALTON.—The Western Cartridge Co. will build an addition to its brass mill and convert part of its present plant into a factory for the manufacture of brass novelties.

CHICAGO.—Goldsmith Bros. Smelting & Refining Co., 29 East Madison St., will build a 125 x 150 ft. plant addition, on 59th St. and Throop St. A. Woltersdorf, 138 North La Salle St., architect.

CHICAGO—The Trustees of the University of Chicago, 134 South La Salle St., will build a laboratory and hospital near the Cook County Hospital. Estimated cost, $400,000.

CHICAGO HEIGHTS.—The Armour Fertilizer Works, Union Stock Yards, Chicago, is having plans prepared for the construction of a one-story, 240 x 520 ft. fertilizer plant. Estimated cost, $500,000. R. C. Clark, c/o company, architect.

WOODRIVER.—The Tidewater Oil Co., Constable Hook, Bayonne, N. J., will build an oil refinery here and extend its pipe line from Woodriver to Tulsa, Okla.

Indiana

LAFAYETTE.—C. S. Barnes is in the market for a second-hand concentration and flotation mill.

Kansas

COTTONWOOD FALLS.—The city has retained Black & Veatch, engineers, Interstate Building, Kansas City, Mo., to prepare plans for complete sewerage system and sewage disposal plant. W. P. Penny, city clerk.

PRATT.—The city has awarded the contract for the construction of a new school, to include a chemical laboratory, to William Foley Construction Co., Dodge City. Estimated cost, $157,087.

Maryland

BALTIMORE.—The city is having plans prepared by L. J. Houston, Jr., engineer, 602 Parkwyrth Ave., for the construction of a sewage disposal plant. Estimated cost, $80,000.

BALTIMORE.—The city will build thirty-two filter operating tables for the Lake Montebello filters. Estimated cost, $26,000. Walter E. Lee, City Hall, engineer.

BALTIMORE.—The Hess Steel Corporation, Biddle St. and Loneys Lane, will receive bids in February for enlarging its plant. Improvements include several one story steel and reinforced-concrete buildings to conform with present structures, additional electric furnaces, rolling mills, etc Estimated cost between $100,000 and $150,000.

Michigan

DETROIT.—Fire recently damaged the chemical plant of F. F. Ingraham Co., 409 West Lafayette Ave. Loss, $100,000.

PONTIAC—The city will install Imhoff tanks and build extensions to treat sewage and prevent dumping it into the Clinton River. Estimated cost, $250,000. H. H. Barnett, City Hall, engineer.

WYANDOTTE.—The city has awarded the contract for the construction of an addition to its filtration plant and pumping station,to the Pitt Construction Co., Fulton Building, Pittsburgh, Pa. Estimated cost, $250,000. Noted Oct. 15.

WYANDOTTE.—The city has awarded the contract for the construction of a rapid sand filtration plant, also an addition to the existing pumping station, to the Pitt Construction Co., Fulton Building, Pittsburgh, Pa. Estimated cost, $185,484. Noted Dec. 15.

Minnesota

CUYUNA.—The Northern Minnesota Ore Co. plans to construct a crushing plant at its Northland Mine and is in the market for grizzlys, feeders, crushers, picking belts, conveyor belts, etc. Estimated cost, $10,000. A. K. Knickerbocker, superintendent.

MANGANESE—The village will soon award the contract for the construction of a sewerage system, to include a sewage disposal plant, septic tank, etc. J. F. Wolff, engineer.

Missouri

CAVE SPRINGS (Chitwood P. O.)—E. James, Connor Hotel, Joplin, will move and erect a complete second-hand mill here.

KANSAS CITY.—The city will build a complete sewerage system and disposal plant. W. B. Penny, city clerk.

VALLEY PARK.—The Universal Glass Company, of Pennsylvania, has acquired a glass plant here comprising eleven acres, and will reopen, remodel and reequip same for its own use. Address owners through R King Kauffman, Mercantile Trust Building, St. Louis.

WACO.—The Waco Mining Co. will build a complete new mill and is in the market for engines, boilers, hoists, crushers, rolls, pumps, rock drills, etc. P. B. Butler, manager.

WEBB CITY.—Crocker Bros. have submitted a plan to the Chamber of Commerce for the construction of a fertilizer plant here, in connection with their packing plant. Project will be investigated. Estimated cost, $50,000.

Montana

HAVRE.—The Board of Health will submit plans not later than May 1, for the installation of a sewage disposal plant. C. W. Swearingen, city engineer.

Nebraska

LAKESIDE.—The Omaha Potash & Refining Co. will install evaporators, coal handling machinery, dryers, crushers, oil engines, etc., in the plant which it plans to build 20 miles south of here. Total estimated cost, $1,000,000. D. E. Wynn Jones, superintendent. Noted Jan. 15.

Nevada

PIOCHE.—The Virginia-Louise Mining Co. plans to install a new compressor plant and enlarge the ore bins at its mine about 4 mi. southwest of Pioche. R. T. Walker, superintendent.

PIONEER.—The Consolidated Mayflower Mines Co. plans to rehabilitate its mine here. Improvements include a new ball or tube mill, new regrinding machinery and the possible enlargement of the regrinding plant. Estimated cost, $10,000. J. B. Kendall, manager.

New Jersey

JERSEY CITY—The Hoboken Electric Chemical Co. submitted lowest bid for supplying Water Department with chloral lime, at 9c. per lb. for liquid chloride and 2.8c. per lb. for bleaching powder.

LINDEN.—The Transatlantic Chemical Co. has awarded the contract for the construction of a two story, 100 x 150 ft. factory, to M. Byron & Co., 430 Westfield Ave., Elizabeth. Estimated cost, $100,000.

NEW BRUNSWICK.—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of a sewage disposal plant at the barracks, here, to Hugh S. Roberts & Co., 1122 Broadway, New York City, N. Y.

New York

NEW YORK.—Bids will be received by Nicholas J. Hayes, Commissioner of Water Supply, Gas & Electricity, Room 2351, Municipal Building, until Feb. 5, for furnishing and delivering liquid chlorine and chloride of lime.

BROOKLYN.—Moller & Schuman, Gerry and Wallabout St., will alter and build extensions to their varnish plant. Estimated cost, $80,000.

CENTRAL ISLIP.—The State Hospital Commission, Albany, has applied to the State Legislature for an appropriation of $100,000 to build underground sewers, etc., and $50,000 for changes in the sewage disposal plant, at Central Islip State Hospital.

NEW YORK.—The Beth Israel Hospital, 70 Jefferson St., will install a laboratory in the sixteen story, 175 x 200 ft. hospital, which it plans to build on Livingston Pl. between 16th and 17th Sts. Total estimated cost, $1,000,000. Louis Abramson, 220 5th Ave., engineer.

NIAGARA FALLS.—The Titanium Alloys Manufacturing Co., 2950 Sugar St., will build a two story, 50 x 50 ft. addition to its plant.

POUGHKEEPSIE.—Bids will soon be received by L. F. Pilcher, state architect, Capitol, Albany, for the construction of a filtration plant and reservoir for the Hudson River State Hospital, here. Estimated cost, $50,000.

RAY BROOK.—The State Hospital Commission, Albany, has applied to the State Legislature for an appropriation of $25,000 to install a new Imhoff system for the sewage disposal at the New York State Hospital for the Treatment of Incipient Tuberculosis.

SYRACUSE.—The Intercepting Sewer Board and the Board of Estimate and Apportionment plan to construct a modern sewage disposal plant at Lake View Point, complete Onondaga Creek improvement and immediate diversion of sewage from barge canal harbor to temporary clarification plant on salt sands.

UTICA.—The State Hospital Commission, Capitol, Albany, will build a two story, 44 x 60 ft. laboratory at the Utica State Hospital. Estimated cost, $50,000.

Ohio

OBERLIN—The Board of Education is having plans prepared by F. C. Warner, architect, 767 Hippodrome Annex, Cleveland, for a two story, 75 x 180 ft. high school building, including chemistry, botany and agricultural laboratories, etc. Total estimated cost, $225,000.

CLEVELAND.—The Board of Public Service, City Hall, will build a filtration plant at the foot of East 49th St., having a daily capacity of 160,000,000 gallons. Estimated cost, $3,500,000. F. H. Betz, 604 City Hall, architect.

CLEVELAND.—The Board of Public Welfare, City Hall, will build a four story addition to the City Hospital, consisting of laboratory, convalescing ward, etc. Total estimated cost, $300,000. Frederich H. Betz, 604 City Hall, architect and engineer.

CLEVELAND.—The Glass Coating Co., 1209 Rockefeller Building, has awarded the contract for the construction of a one story, 165 x 240 ft. glass factory at St. Clair Ave. and Nickel Plate R. R., to include a chemical laboratory, to Harold Ferguson, 66 Beersford Rd. Estimated cost, $80,000.

Oklahoma

DUNCAN.—The city will soon award the contract for the construction of a sewage disposal plant. Estimated cost, $50,000. J. L. Davis, city clerk, Benham Engineering Co., Colcord Building, Oklahoma City, engineer.

IDABEL.—The city is having preliminary plans prepared by the Benham Engineering Co., engineer, Colcord Building, Oklahoma City, for the construction of a complete sewerage system, including main and lateral sewers and a sewage disposal plant. T. J. Bookout, city clerk.

INOLA.—The Liberty Oil & Carbon Co. will build a refinery. Estimated cost, $250,000.

PICHER.—The King Brand Mining Co. of Picher, and Jefferson City, Mo., will open a zinc and lead mine in the Picher District and will soon be in the market for a 200-ton concentrating plant. Address D. M. Oberman, Jefferson City, Mo.

PICHER.—The Oklahoma Lead & Zinc Co. will move its mill from Commerce and erect same here. The company is in the market for boilers, engines, compressors and tables. T. F. Lennan, manager.

TAR RIVER.—The Alexander Mining Co. will move its mill from the Arkansas field and erect same at Tar River. The company is in the market for compressors, engines, rolls, pumps and screens. Estimated cost, $60,000. G. B. Ramsey, manager.

Pennsylvania

BRIGHTON.—The city plans to construct a garbage disposal plant. R. Winthrop Pratt, 716 Hippodrome Building, Cleveland, Ohio, engineer.

WOODLAWN.—The borough has had plans prepared for the construction of a sewage disposal plant. Estimated cost, $50,000. W. M. Anderson, borough engineer.

Tennessee

NEWPORT.—The Unaka Tanning Co. will rebuild its plant recently destroyed by fire. Loss between $300,000 and $500,000.

Texas

DAMON MOUND.—The Universal Sulphur Products Co., incorporated by W. C. Hardcastle, and H. T. Staiti, Chronicle Bldg., Houston, with a capital of $12,000,000, will develop a 7000 acre tract and install a plant for mining raw products, refining it and manufacturing sulphuric acid.

FT. WORTH.—The city is having preliminary surveys made for the construction of a sewage disposal plant. F. J. Von Zuben, city engineer.

HOUSTON.—The Clarendon Refining Co., Clarendon, Pa., has purchased the property of the Crown Oil & Refining Co. and will build a refinery, having a capacity of 5000 barrels. G. E. Colvin, president.

McKINNEY.—A. E. Boger, Dallas, will build a refinery. Estimated cost, $500,000.

RANGER.—Plans are being considered by the City Commissioners for the installation of a new sewerage system and sewage disposal plant.

Virginia

MONTEBELLO.—Richards & Co., Inc., has taken over the Irish Creek Tin Mines and plans to develop same, to include the installation of air drills and the usual equipment. Wiley S. Young, 200 Causeway St., Boston, Mass., treasurer.

NORFOLK.—The Hubbard Fertilizer Co., 802 Keyser Building, Baltimore, Md., has awarded the contract for the construction of a 150 x 192 ft. fertilizer plant at Money Point, near here. W. T. Gregory, 501 Law Building.

Wisconsin

MADISON.—The city plans to improve the sewage disposal plant. Estimated cost, $10,000. E. E. Parker, city engineer.

MILWAUKEE.—The National Oil Products Co., 220 Broadway, New York City, N. Y., has purchased a ten acre site at Keefe and Humboldt Aves., on which it will conduct a modern chemical plant. Estimated cost, $100,000.

WAUSAU.—The city plans to install a filtration plant and air lift system to have a capacity or 4,000,000 gallons; also two reservoirs having a capacity of 250,000,000 gallons. W. G. Kirchoffer, Madison, engineer.

Wyoming

ROCK RIVER.—The Midwest Refining Co. has purchased a site of thirty-eight acres here on which an oil refinery will be constructed.

British Columbia

MERRITT.—The Aberdeen Mines, Ltd., will build a copper mill in the spring. Estimated cost, $100,000. T. J. Corwin, manager.

VANCOUVER.—The International Food Products Co., Ltd., will build a vegetable oil plant to cost $20,000. Machinery costing $20,000 will be installed in same. Singer, Perlstein & Co., c/o the company, architect.

New Brunswick

NASHWAAK.—The Nashwaak Pulp & Paper Co. plans to construct a new mill. Estimated cost, $40,000. N. M. Jones, general manager.

Newfoundland

ST. JOHN'S.—Captain Storm will build a pulp and paper mill on the Terra Nova River. Estimated cost, $1,000,000.

ST. JOHN'S.—The Imperial Oil Co., 56 Church St., Toronto, Ont., will build an addition to its plant here. Estimated cost, $50,000.

Ontario

HAMILTON.—The City Council plans to reconstruct the sewerage system and install a modern sewage disposal plant. E. R. Gray, city engineer.

HAMILTON.—The Dominion Foundries & Steel Co., Ltd., will install a plate mill to roll 42-inch universal and 84-inch sheared plates, and will have a capacity of from 10,000 to 12,000 tons a month.

LINDSAY.—Plans are being considered by the city for the construction of a new sewage disposal plant.

PETERBOROUGH.—The Utilities Commission has purchased the old Carnegie property at the north end of the city and will use same for the construction of a filtration plant.

Saskatchewan

SHAUNAVON.—L. C. Robinson, Calof Building, 3rd Ave., will install a complete new vulcanizing plant and is in the market for machinery.

Coming Meetings and Events

THE AMERICAN CERAMIC SOCIETY will hold a meeting at Pittsburgh, Pa., Feb. 3, 4 and 5, jointly with the U. S. Potters' Association. Following are the professional divisions with their representative chairmen: White-ware and porcelain, Mr. C. L. Sebring; refractories, Mr. A. V. Bleininger; glass technology, Mr. C. H. Kerr; abrasives, Mr. R. C. Purdy; enameled metals, Mr. R. D. Landrum; Terra Cotta and Faience, Mr. F. B. Ortman; brick and tile, Mr. M. P. Blair. Other annual meetings held at the same time are the National Brick Manufacturers' Association, National Paving Brick Manufacturers' Association, National Building Brick Bureau and the National Clay Machinery Manufacturers' Association. There will be an opportunity to inspect the laboratories of the Bureau of Standards, Mellon Institute, University of Pittsburgh.

THE AMERICAN ELECTRO-PLATERS' SOCIETY, NEW YORK BRANCH, will have its 10th annual banquet at the Broadway Central Hotel, Saturday, Feb. 22, at 7:30 p. m.

THE AMERICAN INSTITUTE OF MINING ENGINEERS, which includes the Institute of Metals Division, will meet at the New York Headquarters, 29 West 39th St., Feb. 17 to 20 inclusive.

THE CANADIAN MINING INSTITUTE will hold its twenty-first annual meeting on March 5 to 7, 1919.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will meet at the Waldorf-Astoria and the Hotel Astor, Feb. 3, 4, 5 and 6, 1919.

Industrial Notes

W. S. BARSTOW & Co. announces the completion of a potash recovery plant for the Ironton Portland Cement Co. The Cottrell system of electrical precipitation is used. It is expected that the product will amount to about 30,000 pounds of dust per day and as the raw material is unusually high in potash a large output of this mineral is expected.

E. I. DU PONT DE NEMOURS & Co., Wilmington, Del., has made application to the Federal Trade Commission for enemy patent licenses covering 148 dye patents.

THE AMERICAN PIPE BENDING MACHINE Co., with offices at 39 Pearl St., Boston, Mass., is about to open pipe-bending plants in all large cities throughout the country. The first plant is about ready for operation at Lowell, Mass. "Wonder" pipe benders, manufactured by this company, will be used at all plants. The company will make a specialty of furnishing bent pipe and make delivery of small orders on 48 hours' notice. Each plant will have facilities for turning out from 1000 to 3000 bends per day, and will be in charge of an expert pipe bender. The present company has been capitalized at $100,000, the old company is about to be re-organized with a capital of $1,000,000 to carry on this business.

THE ELECTRIC FURNACE Co., Alliance, Ohio, has closed a contract with the Standard Roller Bearing Co. of Philadelphia for 190 kw. continuous, automatic, heat-treating equipment. The set consists of one 150-kw. electric furnace for hardening and one 40-kw. electric heated oil-drawing bath. There is supplied in addition an oil-quench bath located between the furnace and the electric-heated, oil-drawing bath. Material, which consists of alloy steel balls and ball races, is automatically handled through the furnaces, quench, and drawing baths, in metal baskets.

THE DRAEGER OXYGEN APPARATUS CO., 309 Broadway, has changed its name to the American Atmos Corporation.

THE DETROIT RANGE BOILER & STEEL BARREL Co., Detroit, Mich., is a new company, consolidating the old Detroit Range Boiler Co. and the Toledo Steel Barrel Co. The new organization is capitalized at $1,000,000 and its officers are Edward W. Stoddard, president; Frederick G. Wacker, vice-president; D. B. Duffield, treasurer, and George A. Moore, secretary. At Detroit the company will manufacture the "Perfect" metal bilge barrel and at the Toledo plant they will make "Detroit" drums. There will be branch offices in Philadelphia, Chicago, St. Louis and San Francisco.

THE ASPROMET COMPANY of Pittsburgh, Pa., announces the opening of a sales office in the Schmulbach Building, Wheeling, W. Va., under the direction of Mr. E. A. Short.

THE HAUSER-STANDER TANK Co., Cincinnati, Ohio, has recently moved into enlarged and up-to-date quarters covering about three acres of ground.

THE FULLER-MACCULLOCH Co., Denver, Colo., are erecting in Denver a plant for the manufacture of potash salts, by a new electrochemical process, and in addition are producing phosphates and other like products. They desire catalogs and other literature relating to milling machinery, such as crushers, pulverizers, filters, dryers and evaporating machines.

THE QUIGLEY FURNACE SPECIALTIES Co. has opened a branch office in Providence, R. I., at 302 Turks Head Bldg., in charge of Mr. F. W. Reisman, who has been the Quigley Co.'s Eastern New England representative for hytempite (high-temperature fire brick cement) and insulating brick as well as the air transport system for distributing and burning powdered coal and other fuels.

THE MAYWOOD CHEMICAL WORKS, Maywood, N. J., is the name for the consolidation of the Schaefer Alkaloid Works, the Standard Essence Co. and the Thorium Chemical Co.

THE G. A. BURRELL Co., in cooperation with the R. H. Brownlee Laboratories, has installed at Pittsburgh, Pa., complete equipment for the laboratory and plant testing of chemical processes and especially natural gas, gasoline and petroleum products. It is prepared to handle all problems in connection with these latter substances. Col. G. A. Burrell recently left the Service, where he had charge of the research division of the Chemical Warfare Service. Prior to that time he was in consulting chemical engineering practice, following ten years in the U. S. Bureau of Mines in charge of gas investigations. Dr. R. H. Brownlee spent four years in the laboratories and plant of the Standard Oil Co.'s refinery at Whiting, Ind. Since that time he worked at the Mellon Institute on a gas fellowship, following which he became director of research and development for the Benedum-Trees interests in Pittsburgh, Pa.

THE WHEELER CONDENSER & ENGINEERING Co. of Carteret, N. J., announces that it has obtained from the Schutte & Koerting Co., of Philadelphia, through the Alien Property Custodian, the exclusive right to manufacture and sell steam jet air pumps under Patent No. 968,926 in connection with surface condensers, jet condensers, barometric condensers, vacuum pans and evaporating apparatus.

THE UNIVERSAL ENGINEERING CORPORATION, 1229 Calvert Building, Baltimore, Md., has been organized by John F. Dizu-

weit, William W. Varney, Raymond M. Glacken and Frederick E. Fisher. The company will conduct a general engineering business and research laboratory, and is especially well equipped to solve all problems in connection with electrochemical, metallurgical, mechanical and high-temperature engineering, also the handling of patents, foreign and domestic, investigation, appraisement, litigation, constructing and re-constructing of industrial plants, converting of breweries and distilleries into modern food products plants, etc.

THE LUDLUM STEEL CO., Watervliet, announces the following branches and branch managers: New England territory, Wheelock, Lovejoy & Co., Inc., Cambridge, Mass.; New York, Connecticut and New Jersey territory, Arthur A. Colebrook, 2 Rector St., New York City; Philadelphia territory, E. L. Milnor, 1517 Real Estate Trust Bldg., Philadelphia, Pa.; Railroads, S. T. Pearsons, 47 Terrill St., Rutland, Vt.; New York State, west and central, E. R. S. Reeder, Buffalo, N. Y.; Detroit territory, William A. Edwards, 2012 Dime Bank Bldg., Detroit, Mich.; Chicago territory, C. V. Luin, 928 Peoples Gas Bldg., Chicago, Ill.; Cincinnati territory, K. E. Porter, 816 Mercantile Bldg., Cincinnati, Ohio; Cleveland territory and Pittsburgh territory, V. S. Yarnall, 637 Guardian Bldg., Cleveland, Ohio.

THE PENARROYA MINING AND METALLURGICAL COMPANY of Paris has retained the American firm of Bradley, Bruff and LaBarthe to design a complete lead smelting and refining plant for erection at Penarroya, Spain. The plant will comprise crushing and sampling machinery, multiple hearth and Dwight and Lloyd roasting and sintering equipment, four large lead blast furnaces, one copper blast furnace, lead-copper matte converting plant, zinc desilverizing lead refinery and lead manufacturing machinery. The roasting and metallurgical furnaces will require pulverized coal.

THE UNITED STATES DEPARTMENT OF LABOR, working conditions service, has recently issued a memorandum showing the purposes and methods of industrial medical service in factories and large commercial organizations. Through the division of industrial hygiene and medicine, the working conditions service has laid out the program as follows:

To make studies of working conditions in their relation to health to determine hazardous processes and methods;

To formulate sanitary codes and regulations to meet health hazards in the various industries;

To formulate standards of medical practice in industries, to cooperate in the betterment of medical service in industries and industrial centers;

To determine standards of physiological requirements of various occupations;

To determine methods for proper placement of workers;

To secure statistical data of industrial morbidity;

To promote facilities for the education and training of physicians and sanitarians for industries;

To assist industries in obtaining physicians and other technicians for industrial service;

To disseminate information concerning measures necessary to safeguard workers against industrial health hazards, and to secure cooperation of all elements, governmental and private, in furtherance of the industrial health program.

The working conditions service particularly calls attention to its register of industrial physicians, which will aid manufacturers in getting in touch with physicians especially qualified for industrial service.

HAMILTON & HANSELL, INC., 13 Park Row, New York, has formally opened a steel warehouse at 141 Raymond Street, Brooklyn, which has been in existence since July, 1918, carrying a full line of tool steel and special alloy steels, in rounds, squares, octagons and sheets. Mr. C. U. Ackerlind is manager of the steel department.

THE SLIGO IRON & STEEL CO., Connellsville, Pa., makers of iron and steel bars, expects to make additions to its plants to increase output to 5000 tons monthly.

Manufacturers' Catalogs

THE INDUSTRIAL FILTRATION CORPORATION, 115 Broadway, New York City, has just received from the press a booklet describing andillustrating open tank filters, rotary filters, rotary clarifiers or thickeners, rotary hopper dewaterers and special filtration apparatus.

THE HYGEIA RESPIRATOR CO., 32 Monroe St., Passaic, N. J. A pamphlet describing the Diamond-Mask model "C" respirator.

E. H. SARGENT & CO., Chicago, Ill., calls attention in a pamphlet to Sargent's electric drying oven with automatic temperature control, giving directions for operating.

THE P. H. AND F. M. ROOTS CO., Connersville, Ind., calls attention to Catalog 68 on its rotary blowers. This is an attractive 48-page catalog which describes and illustrates many different types of blowers.

THE UNION THERMOMETER COMPANY, INC., 1301 Boston Road, New York City, has issued a special descriptive folder on chemical or laboratory thermometers, including the length of scale, range of scale and price per piece and per dozen.

THE GREEN ENGINEERING CO., East Chicago, Ind., has issued a 16-page booklet on Green materials transfer and storage hopper which is finding many uses in the chemical and allied fields for storing such materials as granular fullers earth, gilsonite, kieselguhr, ferrosilicon, bauxite, etc.

THE EDW. R. LADEW CO., INC., Glen Cover, N. Y., has issued an attractive catalog entitled "Ladew Leather Belting." It has 108 pages and illustrations and descriptive matter explaining step by step the operations involved to make the raw material into the finished product. A discussion is also given of belt engineering and belting economies.

MILLIKEN BROTHERS MFG. CO., INC. Woolworth Bldg., New York, call attention to an attractive 24-page booklet entitled "Space and Speed in Steel Buildings" descriptive of the standardizing truss unit system of building construction. Many interesting illustrations are given.

RAYMOND BROS. IMPACT PULVERIZER CO., Chicago, Ill.: Catalog No. 13 is a very attractive 64-page booklet on grinding, pulverizing and separating machinery. Illustrations and descriptive matter explain roller mills and pulverizers equipped with air separation for grinding all kinds of materials to powdered form. This catalog not only covers Raymond equipment but it gives some very good general ideas regarding pulverizing problems.

JOHN SIMMONS CO., 110 Centre Street, New York, calls attention to a 12-page booklet on the Leinert automatic gravity scales, for the automatic accurate weighing of liquids such as water, oil, sugar-juice spirits, petroleum, brine, acids, chemicals, etc. A description of the different uses for this scale, together with illustrations, is given.

THE RUTH COMPANY, Denver, Colo., describes and illustrates the Ruth flotation machine in a 12-page booklet. A copy can be had on request.

THE LINK-BELT COMPANY, Chicago, Ill., has just received from the press Book No. 353, "Economical Handling of Coal and Ashes and Reserve Coal Storage." By Henry J. Edsall. The booklet contains 52 pages of descriptive matter together with illustrations which are reprinted from a series of articles in *Steam* during 1917-1918. The same company also issues Book No. 333 "Link-Belt Equipment for the Handling and Preparation of Coal at the Mines." This attractive catalog contains 88 pages and illustrates coal tipples, conveyors, washeries and other equipment used at the mines.

THE CUTLER-HAMMER MFG. CO., Milwaukee, Wis., is distributing a novel two-page envelope folder which illustrates and enumerates the advantages of the C-H 91-16 starting switch for alternating current squirrel cage motors.

THE STAR BRASS WORKS, Chicago, Ill., has just received from the press Bulletin No. 4 pertaining to Spray cooling equipment as adapted for the re-cooling of condensing water for power and industrial plants.

THE FOXBORO CO., INC., Foxboro, Mass., calls attention to Bulletin 115, dated December, 1918, on power plant instruments which are used to reduce boiler-room expenses. This is an 8-page booklet, illustrated, which should be helpful to engineers who have not the time to look through the large bulletins issued by this company.

THE STEERE ENGINEERING CO., Detroit, Mich.: Bulletin No. 35 entitled "Tar Cameras for Colorimetric Tar Determination." This is an attractive 12-page booklet, well illustrated and supplemented by a colorimetric chart.

THE JOHN F. BYERS MACHINE CO., Ravenna, Ohio, has just received from the press Bulletin 1015 describing Model "9" autocrane. This 24-page catalog shows the various uses in many fields for the autocrane.

THE WALTER A. ZELNICKER SUPPLY CO., St. Louis, Mo., calls attention to Bulletin No. 250, which lists and illustrates rails, locomotives, cars, cranes, shovels, pipe, machinery, tanks, steel piling, power plant equipment, machine tools, wire rope, hoists and contractors' equipment. This bulletin is free to the trade.

THE GRISCOM-RUSSELL CO., 90 West St., New York: Bulletin No. 901 describes and illustrates the Multiwhirl Cooler, one of the uses of which is the removal of heat of waste liquors from chemical plants.

THE LAKEWOOD ENGINEERING CO., Cleveland, Ohio, sends as a New Year's greeting a very attractive booklet entitled "The Road to Peace," which is exceedingly interesting. It has 42 pages 10¾ in. by 14¼ in., printed in two colors and is profusely illustrated. Pictures are given of portable track, switches, and equipment being loaded onto a steamer for service overseas, military portable track piled in a French yard awaiting engineer requisition, and many others. One of especial interest is entitled "Blocking Off the Hun Advance Before the Second Battle of the Marne," which was snapped by a camera man with the American Expeditionary Forces and which shows a mine blowing up a bridge carrying Lakewood track.

New Publications

SOUTH DAKOTA SCHOOL OF MINES, Department of Geology and Chemistry, Rapid City, South Dakota, Bulletin No. 12 entitled "The Occurrence, Chemistry and Uses of Tungsten," with special reference to the Black Hills of South Dakota, by J. J. Runner and M. L. Hartman, including a bibliography of tungsten by M. L. Hartman, dated Sept., 1918.

THE FEDERAL BOARD FOR VOCATIONAL EDUCATION has issued a series of Opportunity Monographs. Vocational Rehabilitation Series, No. 5 "Army Occupations as Preparation for Civilian Employment"; No. 7 "The Metal Trades"; No. 8 "Factory Woodworking Trades"; No. 10 "Forestry Pursuits"; No. 11 "Automobile Maintenance and Service"; No. 12 "Employment Management" and No. 17 "The Practice of Medicine as a Vocation." These pamphlets are gotten out to aid the disabled soldiers, sailors and marines in choosing a vocation.

NEW BUREAU OF STANDARDS PUBLICATIONS: Tech. Paper No. 117 "Toluol Recovery" by R. S. McBride, C. E. Reinicker and W. A. Dunkley; Circular No. 3 "Design and Test of Standards of Mass." This third edition dated Dec. 23, 1918, supersedes the second edition entitled "Verification of Standards of Mass" issued Jan. 10, 1907.

NEW BUREAU OF MINES PUBLICATIONS: Bull. 154: Mining and Milling of Lead and Zinc Ores in the Missouri-Kansas-Oklahoma Zinc District. By Clarence A. Wright; Bull. 163: Methods of Shutting Off Water in Oil and Gas Wells. By F. B. Tough: Bull. 170: Extinguishing and Preventing Oil and Gas Fires. By C. P. Bowie; Tech. Paper 152: The Inflammability of Aluminium Dust. By Alan Leighton; Tech. Paper 171: Method of Least Squares Applied to Estimating Errors in Coal Analysis. By J. D. Davis and J. G. Fairchild; Tech. Paper 198: Sulphur Dioxide Method for Determining Copper Minerals in Partly Oxidized Ores. By Charles E. Van Barneveld and Edmund S. Leaver; Tech. Paper 200: Colloids and Flotation. By F. G. Moses; War Minerals Investigations Series No. 3 dated Dec., 1918, entitled "Preparation of Crucible Graphite" by Geo. D. Dub; Bull 161: Law Serial 13 California Mining Statutes Annotated. By J. W. Thompson, including all California mining laws.

NEW UNITED STATES GEOLOGICAL SURVEY PUBLICATIONS: II:36, Stone in 1916. By G. F. Loughlin. (Mineral Resources of the U. S., 1916, Part II, pages 993-1087), published Nov. 25, 1918; II:18, Asphalt. Related Bitumens and Bituminous Rock in 1917. By John D. Northrup. (Mineral Resources of the U. S., 1917, Part II, pages 232-251), published Oct. 22, 1918; II:22. Fluorspar and Cryolite in 1917. By Ernest F. Burchard. (Mineral Resources of the U. S., 1917, Part II, pages 293,304), published Nov. 20, 1918; I:9. Gold, Silver, Copper and Lead in Alaska in 1917, Mines Report. By G. C. Martin. (Mineral Resources of the U. S., 1917, Part I, pages 131-145), published Nov. 21, 1918.

Power Data for Electrolytic Zinc

By G. H. Clevenger and F. S. Mulock

THE accompanying straight line diagram shows graphically the relationships between the principal electrical data involved in the production of electrolytic zinc. It will be noted that each vertical line is subdivided into a logarithmic scale. The position and scale of the heavy lines A, C, E and IJ are first arbitrarily laid off.

The position and scale of line B, which represents the product of A, C and a constant, is then determined from the arbitrary scales on lines A and C. As line A represents ampere-hour efficiency and line C current in amperes, their product, when multiplied by time and the electro-chemical equivalent of zinc, will give the weight of zinc deposited for that time. Here the constant used was such that the scale of line B represents pounds of zinc per 24-hour day.

Similarly, the product of line C, representing current in amperes, and line E, representing voltage, is given on line D, which represents power in kilowatts.

Line D, representing kilowatts, multiplied by 24, gives kilowatt-hours per day. This product divided by line B, representing pounds of zinc per day, gives kilowatt-hours per pound of zinc, which is represented by scale F on line FG.

Using the theoretical decomposition voltage of the electrolyte and the electrochemical equivalent of zinc, it is possible to determine the theoretical kilowatt-hours required per pound of zinc. This value divided by the actual number of kilowatt-hours per pound of zinc (as found on scale F) gives the power efficiency. Scale G gives the power efficiency for a zinc sulphate electrolyte.

Line IJ gives the cost of power both in cents per kilowatt-hour and in dollars per kilowatt-year. From scale J of line IJ and scale F of line FG is determined the line H, which represents the cost of power in cents per pound of zinc.

The following problem will illustrate the use of the diagram:

Given: 1. Current, 5000 amperes. 2. Ampere-hour efficiency, 90 per cent. 3. Voltage, 3 volts. 4. Cost of power, $20 per kilowatt-year.

To find: 1. Pounds of zinc deposited per day. 2. Power in kilowatts. 3. Kilowatt-hours per pound of zinc. 4. Cost of power in cents per pound. 5. Power efficiency.

1. Place a straight edge on 90 of the A scale and 5000 of the C scale. Read pounds of zinc per day (291) at point where straight edge intersects the B scale.

2. Set at 5000 on scale C, and 3 on E, and read power (15 kw.) on D.

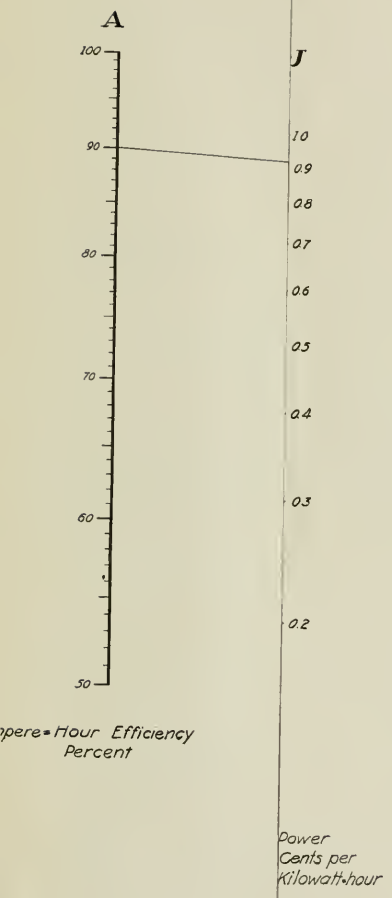
3. Set at points determined in 1 and 2, i.e., 291 on scale B and 15 on scale D; read kw.-hr. per lb. of zinc (1.24) on scale F.

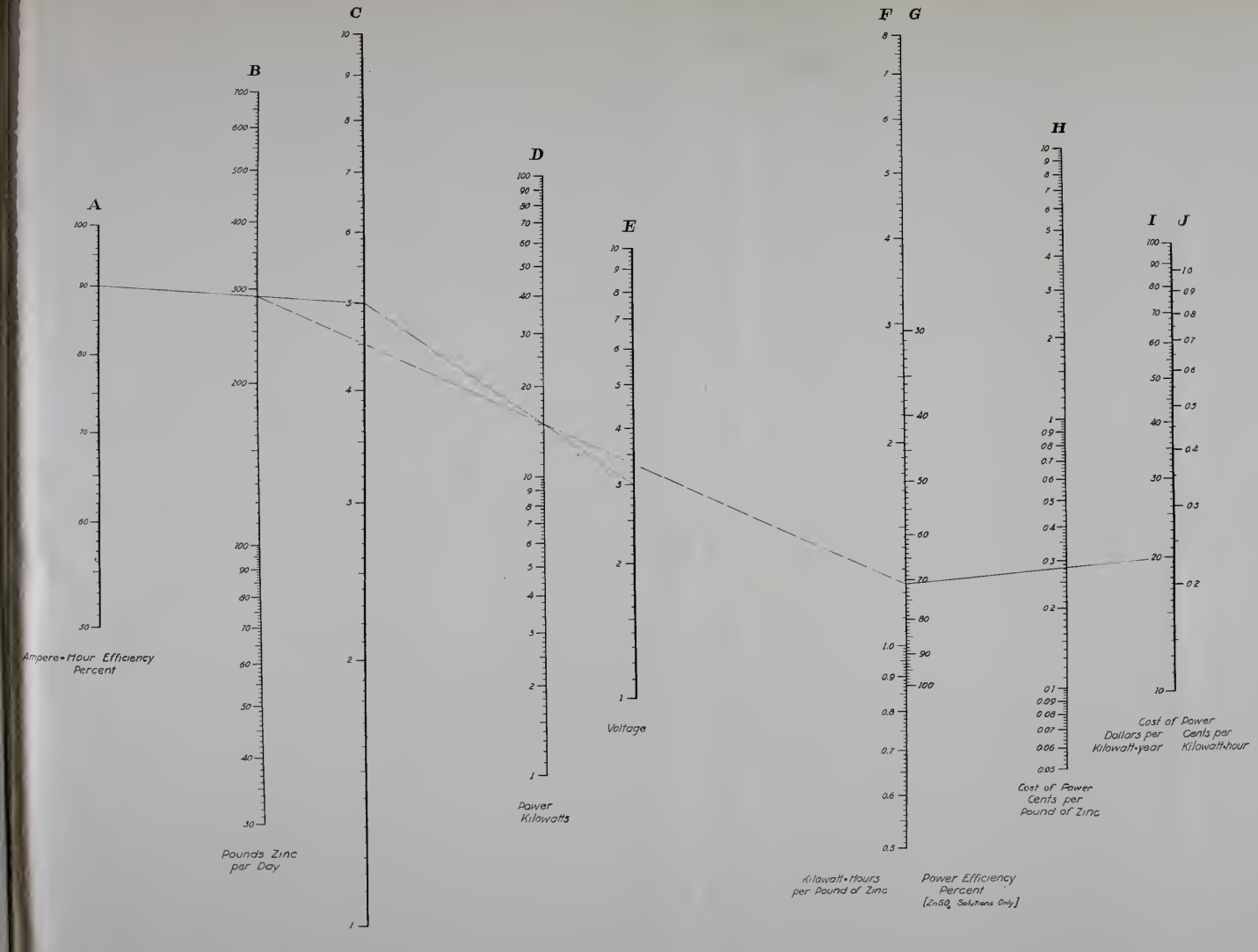
4. Set at 1.24 on scale F and 20 on scale I, and read the cost of power per pound of zinc (0.283 cents).

5. With the same setting as in 3, if the electrolyte is zinc sulphate, read the power efficiency (71 per cent) on scale G. (This scale cannot be used for electrolytes other than zinc sulphate.)

Note: The voltage to be used on scale E is the voltage per cell. When cells are connected in series, divide the total voltage by the number of cells. The output of each cell may be ascertained by using the average current per cell on scale C. The total output of the plant may then be found by multiplying this result by the number of cells in use.

Similar straight line diagrams can be prepared showing the relationship between the electrical data involved in the electrodeposition of the other metals.





Power Data for Electrolytic Zinc

By G. H. Clevenger and F. S. Mulock

THE accompanying straight line diagram shows graphically the relationships between the principal electrical data involved in the production of electrolytic zinc. It will be noted that each vertical line is subdivided into a logarithmic scale. The position and scale of the heavy lines A, C, E and IJ are first arbitrarily laid off.

The position and scale of line B, which represents the product of A, C and a constant, is then determined from the arbitrary scales on lines A and C. As line A represents ampere-hour efficiency and line C current in amperes, their product, when multiplied by time and the electro-chemical equivalent of zinc, will give the weight of zinc deposited for that time. Here the constant used was such that the scale of line B represents pounds of zinc per 24-hour day.

Similarly, the product of line C, representing current in amperes, and line E, representing voltage, is given on line D, which represents power in kilowatts.

Line D, representing kilowatts, multiplied by 24, gives kilowatt-hours per day. This product divided by line B, representing pounds of zinc per day, gives kilowatt-hours per pound of zinc, which is represented by scale F on line FG.

Using the theoretical decomposition voltage of the electrolyte and the electrochemical equivalent of zinc, it is possible to determine the theoretical kilowatt-hours required per pound of zinc. This value divided by the actual number of kilowatt-hours per pound of zinc (as found on scale F) gives the power efficiency. Scale G gives the power efficiency for a zinc sulphate electrolyte.

Line IJ gives the cost of power both in cents per kilowatt-hour and in dollars per kilowatt-year. From scale J of line IJ and scale F of line FG is determined the line H, which represents the cost of power in cents per pound of zinc.

The following problem will illustrate the use of the diagram:

Given: 1. Current, 5000 amperes. 2. Ampere-hour efficiency, 90 per cent. 3. Voltage, 3 volts. 4. Cost of power, $20 per kilowatt-year. To find: 1. Pounds of zinc deposited per day. 2. Power in kilowatts. 3. Kilowatt-hours per pound of zinc. 4. Cost of power in cents per pound. 5. Power efficiency.

1. Place a straight edge on 90 of the A scale and 5000 of the C scale. Read pounds of zinc per day (291) at point where straight edge intersects the B scale.

2. Set at 5000 on scale C, and 3 on E, and read power (15 kw.) on D.

3. Set at points determined in 1 and 2, i.e., 291 on scale B and 15 on scale D; read kw.-hr. per lb. of zinc (1.24) on scale F.

4. Set at 1.24 on scale F and 20 on scale I, and read the cost of power per pound of zinc (0.283 cents).

5. With the same setting as in 3, if the electrolyte is zinc sulphate, read the power efficiency (71 per cent) on scale G. (This scale cannot be used for electrolytes other than zinc sulphate.)

Note: The voltage to be used on scale E is the voltage per cell. When cells are connected in series, divide the total voltage by the number of cells. The output of each cell may be ascertained by using the average current per cell on scale C. The total output of the plant may then be found by multiplying this result by the number of cells in use.

Similar straight line diagrams can be prepared showing the relationship between the electrical data involved in the electrodeposition of the other metals.

Published SEMI-MONTHLY *on the* FIRST *and* FIFTEENTH *of each month*

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

McGRAW-HILL COMPANY, INC.
Tenth Avenue at 36th Street
NEW YORK

JAMES H. McGRAW, President
ARTHUR J. BALDWIN, Vice President E. J. MEHREN, Vice President
EDWARD CALDWELL, Treasurer JAMES H. McGRAW, JR., Secretary

TELEPHONE, 2840 Greeley CABLE ADDRESS, Machinist, New York

WASHINGTON, Colorado Bldg. SALT LAKE CITY, Newhouse Bldg.
CHICAGO, Old Colony Bldg. PHILADELPHIA, Real Estate Trust Bldg.
SAN FRANCISCO, Rialto Bldg. CLEVELAND, Leader-News Bldg.
LONDON, Hastings House, Norfolk St., Strand.

H. C. PARMELEE, Editor
ELLWOOD HENDRICK, Consulting Editor
ERNEST E. THUM, Western Editor
WALLACE SAVAGE, Assistant Editor

J. MALCOLM MUIR, General Manager

Yearly Subscription price for United States, Mexico and United States dependencies, $3; all other countries, $4. Single Copy, 25c.

When change of address is ordered, the NEW and the OLD addresses must be given. Notice must be received at least 10 days before change takes place. No back copies for more than three months.

Copyright, McGraw-Hill Co., Inc., 1919. Entered as second-class matter July 13, 1918, at the Post Office at New York, N. Y., under the Act of Congress of March 3, 1879.

Circulation of this issue 12,750 *copies*

CONTENTS *for* February 15, 1919

EDITORIAL
A New View of Gas Warfare....145
Dislocation of the Copper Industry....145
Proposed Improvements in America's Patent Procedure 146
Restoring the Dollar's Value....147
Western Chemical and Metallurgical Field....148
Report of the Patent Committee to the National Research Council....150
Research Vacancies in the University of Illinois....151
Secretary Lane Seeks Survey of Power Resources....151
Deadlock on Water Power Legislation....151
Chemical Warfare—A New Weapon....152
Electrolytic Deposition of Zinc....155
The Aluminium Bronze Industry. By *W. M. Corse*....162
Future of the Barium Industry. By *William H. Rollin*....163
The Manufacture of Hydrocyanic Acid. By *H. A. Pelton* and *M. W. Schwarz*....165
Influence of Temperature Upon the Action of Slag Upon Refractory Materials. By *Raymond M. Howe*....167
Mesothorium Work of the Bureau of Mines....168
Flotation of Oxidized Ores of Lead. By *Glenn L. Allen*....169
Fuel Economy in the Boiler House—I. By *John B. C. Kershaw*.176
Electric Pig Iron After the War. By *Robert Turnbull*....178
A New Bronze-Alloy in Norway....179
Pittsburgh Meeting of the American Ceramic Society....180
Paper Associations Hold Joint Convention....184
American Sulphur Industry Expanding....186
Gold and Silver Production in the United States in 1918....188
Ecuador Establishes Crude-Salt Monopoly....188
Aids to Foreign Trade....189
British Import Restrictions....189
Acetone. By *H. P. Bassett*....190
Electric Steel Castings....190
Hydrogen Recorder....191
Ordnance Scrap Material for Sale....191
Synopsis of Recent Chemical and Metallurgical Literature....192
Book Reviews....194
Personal....194
Current Market Reports—Non-Ferrous, Iron and Steel and Chemical Markets and Chemical Price List....194
Industrial—Plant Construction, Coming Meetings and Events, Manufacturers' Catalogs, Stock and Bond Quotations...199

A New View of Gas Warfare

WHEN the Germans introduced poison gas as a means of attaining their military ends they were universally condemned for committing a fiendish act; and military critics referred to it as a reversion to the use of the stink-pot by the Chinese. It was, indeed, a detestable method of warfare that had not occurred to the Allies; or if it had occurred to them it was rejected as abhorrent. But in order to fight the devil with fire the Allied and American armies began extended research in the manufacture of poison gases and protective masks, and ultimately excelled their enemies in this mode of warfare, just as they did in all others. Indeed the Germans were being rapidly gassed into submission and would have been given still larger doses but for their sudden capitulation.

It is likely that our first unfavorable impressions of gas warfare have become fixed in our minds, so that a defense of the practice will be more or less shocking to the layman. From a military aspect, however, gas has such favorable possibilities that it is regarded in some quarters as one of the most effective and humane weapons of the future. Our readers will be especially interested in an article on another page giving the views of Brigadier General Amos A. Fries, who was recently interviewed by a member of our editorial staff. General Fries was in charge of the Chemical Warfare Service in France, and speaks from experience. He finds gas a weapon of great possibilities; effective against an unprepared foe, but of little or no avail where ample protection is provided. Less frightful in maiming and wounding men, it is more humane than shrapnel and high-explosive shells; and there is a lower death rate from gas casualties than from those caused by gunfire. As a means of rendering mobs tractable, lachrymator gases may find useful application in civil life. On the whole there seems to be a possibility of developing this unhappy offspring of iniquity into something useful, and we commend a careful reading of General Fries' views.

Dislocation of the Copper Industry

ARGUING, at this late date, the wisdom in the continuance of copper production at a maximum rate after the signing of the armistice had absolutely killed the market both for governmental and individual account is hardly of value. The large producers and the Government must have seriously misjudged the American and the world market conditions in order to have piled up a billion pounds of high-cost copper, finished and in process—the present visible stock,

according to reliable estimates. November and December passed without a single large sale. Organizing to control export trade, the copper producers formed a *de facto* trust and in January set the export price at 23 cents—purely a figure of hope, since foreign companies could readily cover current needs by purchasing the reserve stocks held by their Governments at a materially lower figure. Nothing prevented the American producers from almost unanimously asking 23 cents for local delivery; on the other hand, nothing forced American consumers into buying at that price. In the face of this stalemate, curtailment became the order of the day, and at present the output is probably at the rate of 100,000,000 pounds per month.

A reduction in output to about 60 per cent normal naturally laid off a number of men in the mines and mills. Avoidance of serious unemployment was perhaps the sole justification of previously maintaining large over-production. This surplus labor added to the ranks of returning soldiers created such a serious outlook that Secretary of Labor Wilson held a conference with labor union representatives from Montana, Utah and Arizona early in February to solve if possible the riddle. These meetings listened to a statistical statement of the present copper market, an address from John D. Ryan, explaining the financial position of the producing corporations, and various schemes from the workmen designed to maintain war-time wages and employment.

This seems impossible of attainment. Sales in quantity began to occur during the first week in February at a fraction over 18 cents. Immediately thereafter the large producing companies posted notices that the wages would again be determined by a sliding scale, based on the market price of the metal, a system largely used in the industry and in many camps sanctioned by contracts between companies and unions. In the absence of any market, wages for February will be figured either on a basis of 20-cent January copper or on the daily current price (depending upon custom); either plan will involve a horizontal wage reduction of from 75 cents to $1 per day. Even at this, the daily rates are 50 cents or more higher than existing agreements call for, since the wages recently paid were accepted as the scale for 26-cent copper, while as a matter of fact, it more nearly approximates the 30-cent scale, maintained without reduction by agreement with the War Industries Board. The Anaconda Copper Mining Company also announced that no further decrease in wages is anticipated, should the market fall below 17 cents.

The unfortunate feature of the labor situation in the copper industry is that the miners decline to accept the wage reduction which accompanies the decreased price for the metal. The sliding wage-scale based on metal prices is always acceptable to the miner as long as prices are rising, but his memory is rather short when the time comes for him to perform his part of the contract and accept the wage reduction. The consequence is that mining and milling operations are practically suspended in the Butte district owing to a strike fomented by the notorious and vicious I. W. W. The fear has been expressed that the dissension will spread throughout the other Western copper districts. We can imagine that the companies will be glad of an excuse to close their properties in view of the present high cost of production and the prospect of a falling market. The miners have nothing to gain except through a straightforward and generous acceptance of their share of the loss which the sudden ending of the war brought to the industry.

Proposed Improvements in American Patent Procedure

WHEN the Commissioner of Patents in 1917, with the approval of the Secretary of the Interior, requested the National Research Council to investigate our Patent Office and its procedure, a step was taken which we are so bold as to believe will result in remedying some of the imperfections on our patent system. These have long been apparent to those who have much to do with the Patent Office. Considering the vital part played by this institution in our national life, it is important that it be made as efficient and effective as possible. No organization is better qualified than the National Research Council to appreciate the excellence or deficiency of the Patent Office, and the recommendations of a committee from that body should carry weight with Congress when it is asked to pass the necessary bills.

In a report of the patent committee to the Council it is recommended that a simple program of four features be adopted, and that the necessary legislation be obtained from Congress to put the proposals into practice. The first proposal concerns a single Court of Patent Appeals to supersede the nine Circuit Courts of Appeals, as far as patent cases are concerned. The second recommends that the Patent Office be made a separate institution, independent of the Interior or any other department of the Government. The third relates to substantial increases in the force employed in the Patent Office and in the salaries paid. The fourth seeks to make it possible for a patentee to obtain not only an injunction against an infringer in a case where a patent is adjudged valid, but also a reasonable royalty or other form of general damages.

There is no doubt that some step should be taken to remedy the farcical situation which can and does now arise in the adjudication of patents by our Circuit Courts of Appeals. As matters stand at present it is possible for the same case to be decided differently in two different circuits. Obviously a single agent is much preferable to nine having equal authority. But the question has been raised previously as to the wisdom of adjudicating patents *after* they have been granted instead of *before* they are issued. Those to whom letters patent have proved an expensive form of introduction to the Supreme Court have some ground for feeling that a court of experts weighing the claims of contestants before a patent is issued would be a quieting factor in our industrial life. Perhaps the committee of the National Research Council has considered this alternative and has concluded that a Court of Patent Appeals is preferable. Certainly it will be much preferable to our present courts for patent cases.

The movement to make the Patent Office a separate institution is believed to be in the interest of better administration. At present the Secretary of the In-

terior is at best a figurehead in its affairs, and the Patent Office suffers by irrelevant comparisons with other bureaus in the Department of the Interior. Only the highest approval can be given to the recommendation that the force of examiners and clerks be increased and that their salaries be raised to figures comporting with their ability. It is a reflection on the country that the salaries of examiners have been increased only 10 per cent since they were fixed in 1848! As to compensation for infringement of patents, we are in accord with the committee in seeking to secure a financial return to an inventor whose rights are violated.

Injunctions buy no bread for the winner, nor do they constitute a serious punishment to the loser. Money compensation would be more tangible justice to the inventor and probably a stronger deterrent against deliberate infringement.

Restoring the Dollar's Value

TO RE-ESTABLISH business on a sound basis, indeed to re-establish industrial activity at all, it is necessary that the old-time value of the dollar be largely restored. It is impossible to change suddenly the value of the dollar and then have everything move substantially as before. No real prosperity can occur. The proper conception of prosperity is that of making progress, of obtaining new things. A state of society is conceivable in which men would merely produce the same quantity of material year in and year out, consume the same quantity, and be contented. They would merely be doing the same things over and over again. To conceive such a condition requires much imagination, for the concept is not in keeping with our traditions or habits of thought. Often we say that the luxuries of one day become the necessities of the next, which of course means that progress is essential to contentment, for while one might get along without luxuries and be somewhat contented he would certainly not be contented when those articles had become necessities.

Prosperity, then, not merely being busy but making progress, means development, doing new things, making new products. All this involves the providing of additional facilities, for which capital must be expended, changing from liquid to fixed form. More or less the capital invested in any year comes into competition with the capital that was invested in previous years. If the capital already invested was at a certain scale of values, of prices for commodities and labor involved in making the investment, and the new capital must be invested with a much higher scale of values obtaining, the competition places the new capital at a great disadvantage.

At a time like this capital shrinks from seeking investment in works of construction, which are necessary to our prosperity and advancement, both because it must come in competition with capital already invested to better advantage and because it faces the menace of a future time when it may be possible to invest capital to better advantage, through lower prices then obtaining for labor and materials.

If the investments now existing in the country had appreciated in intrinsic value, keeping pace with the reduced purchasing power of the dollar, the condition might not be unsatisfactory. Things might possibly work out fairly well. This, however, is not the case by any means. The wealth of the country is not estimated at much more than before the war-time inflation occurred. The plight of most public service corporations is a practical example. If, assuming that the purchasing power of the dollar has been cut in half, the value of their properties, measured in dollars, had doubled, they would obviously be in very happy position; but the actual fact is that through the decreased purchasing power of the dollar their cost of operation is increased and the intrinsic value of the properties is decreased rather than increased. High wages cannot maintain high commodity values, nor can high commodity values maintain high wages. The value of existing properties, buildings, bridges, power plants, factories and other investments can, however, exercise an influence to pull down investment costs when they are so high that capital does not seek outlet through such investments. Inevitably this pulling down process is going to occur, and it is unwise not to face the fact squarely. If through lack of understanding people do attempt to resume full-time activity without the necessary adjustments having been made, there will simply be so much the more to adjust at some later time.

No one, of course, can intelligently argue that prewar conditions and prices must return, or ever will return in full. To an extent conditions have changed. The position of labor has been altered by the war and former conditions will never be fully restored. The common laborer wants more, and will get more, for his labor in proportion to the pay of the more highly skilled man.

The war has shown that it does not require so long for a man to become skilled after all, and the fact that a man's work is skilled and therefore interesting is going to be taken as part of his reward for doing the work. Furthermore, the change that has been working for centuries must be regarded as having been in operation, double time, during the period of the war. The value of the dollar decreases from century to century. In 1897 and 1898 very low prices obtained in the United States. In succeeding years prices advanced rather steadily and there were those who looked for them to return eventually to the old level. That was a mistaken apprehension. Whether it is the increasing volume of money and credit, according to the quantitative theory, or a combination of influences, need not be discussed. It may be accepted as reasonably certain that with various fluctuations the value of the unit of money tends to decrease. If the price of a given commodity declines, it is merely a temporary fluctuation, an adjustment of a too great advance previously, or a decrease in the cost of producing the article.

Thus commodity prices and wage rates cannot be expected to be restored to the plane which they occupied before war was declared, but there must be a very considerable readjustment in that direction before industry can go ahead, development be undertaken and the people become really prosperous.

Western Chemical and Metallurgical Field

Secondary Mining Schools in Nevada

THE fifth session of the prospector's short course was held at the Mackay School of Mines at Reno, Nevada, during January. The majority of those attending were miners and mining men, although there has always been a considerable number of other trades or professions who are interested in prospecting as a side issue. Such courses offer a good opportunity for one to brush up his knowledge of prospecting, assaying, mineralogy and geology.

While similar courses have been instituted in several Western mining schools, the Mackay school at Reno is unique in instituting a system of secondary mining education for miners and mill-men, which includes a traveling mining school, which moves from camp to camp, visiting any localities which obtained an advance registration of at least twenty men, and continuing for one or two periods of three months as the attendance warranted.

Beginning with one school, operated as an extension department of the University of Nevada, the system has grown until it now consists of five distinct schools. Four of these are permanently located at Virginia City, Tonopah, Goldfield, and Ely, while the fifth is a traveling school at present in session at McGill. The only requirement for entrance into these schools is the ability to talk and read English, and while the instruction is elementary and practical in character thirty-seven different courses are offered and may be combined into various groupings sufficient to better the training in many vocations. The regular class work consists of two hours daily, which is as much as can be expected from men who are working continually at their trade. Instruction is given at two different two-hour periods to accommodate men working on different shifts, but the laboratories are open at all times during the week.

It is evident that in these schools no attempt can be made to train mining engineers and metallurgists. The object rather is to acquaint the student with some of the technical theory underlying his everyday work, thus making him a more intelligent and efficient workman and citizen. The young men who have a common school education and who do well in these secondary schools are offered every encouragement to go to the Mackay School of Mines for engineering training.

1918 Mineral Production in British Columbia

BROADLY speaking, the industrial conditions during the past year have not been unsatisfactory; and while it is not anticipated that the production will equal the record of 1916, it should compare very favorably with that of 1917. According to the January Bulletin of the Canadian Mining Institute, the production of coal for the nine months of 1918 showed an increase of 255,188 tons as compared with the output for the corresponding period of 1917. Production during the last quarter of the year has been well maintained despite the fact that operations, especially in the Crowsnest area, have been impeded by strikes and by the recent epidemic of influenza. So far as copper is concerned the total output for nine months of 1918, according to the official records, was 45,518,223 lb. as compared with a total production during 1917 of 59,700,565 lb. The value of the silver produced owing to the advance in the market price of this metal is likely to show an increase over last year; the lead and zinc output will probably be less than last year. The suspension of operations at the Rossland mines for a considerable period during the year will inevitably affect the showing as regards the province's gold production, but this has been more than offset by the entry of the Surf Inlet mine into the productive class. Preliminary figures follow:

Placer gold	$300,000
Lode gold	$3,627,500
Copper, pounds	62,000,000
Silver, ounces	2,460,000
Lead, pounds	20,500,000
Zinc, pounds	23,055,000

Manufacture of Pure Stick Caustic Potash

AMONG the many chemical products obtained exclusively from Germany before the war is caustic potash in the form of pure white sticks, having a content of 85 per cent or more of KOH and designated as the U. S. P. quality. The chemical literature is lacking in description of processes for making this material, especially from the grades of raw material available in this country during the past two years. In establishing a plant having a capacity for producing this material of 1000 lb. per day the C. F. Burgess Laboratories claim to have developed a strictly American process for producing a U. S. P. grade of caustic from American raw materials.

The raw materials employed are crude caustic from wood ashes and potash derived from the alunite process. The white sticks as marketed are about 10 cm. in length and weigh approximately 10 g. While the tonnage demanded for this product is small, it is nevertheless important for laboratory use, in gas analysis, in pharmaceutical preparations and in various chemical products such as special shaving soaps and the like.

Penn-Wyoming Copper Co. Sold

WE HAVE been advised that the entire assets of the Penn-Wyoming Copper Co., Encampment, Wyoming, owner of the Saratoga & Encampment Railroad, the Ferris Haggerty and Doane-Rambler mines at that place, have been purchased by the Morse Bros. Machinery & Supply Co. of Denver, Colo.

The various subsidiary companies purchased and their respective bond issues follow:

Ferris Haggerty Copper Mining Co	$1,000,000
Battle Lake Tunnel Site Mining Co	750,000
Saratoga & Encampment Railroad Co	750,000
Encampment Smelting Co	500,000
Encampment Tramway Co	350,000
Encampment Pipe Line Ditch Co	100,000
Emerson Electric Light Co	50,000
Encampment Water Works Co	50,000
Carbondale Coal Co	20,000
North American Mercantile Co	22,000
Encampment Town Lot & Land Co	8,000
Total bond issues	$3,600,000

The stock of the Penn-Wyoming Copper Co. was $10,000,000. This company was the successor of the North American Copper Co., the promotion of WILLIS GEORGE EMERSON, who recently died in Los Angeles, the Penn-Wyoming company taking over the property in 1904 and operating it under the most unfortunate conditions of fire losses and financing of the railroad until 1907, when it was closed. Numerous attempts were made to reor-

ganize and resume operation. Company dissension arose during the efforts to reorganize, a receiver was appointed and litigation commenced which only ended in the Court of Appeals. The sale of the property to the bondholders' protective committee and the purchase by the Morse Bros. Machinery & Supply Co. from that committee brings the history to date of a mine with a record of having produced more than 10,000,000 lb. of copper since its discovery in 1898 by ED HAGGERTY.

The records of the Penn-Wyoming Copper Co. show a production of 6,414,011 lb. of copper from 59,000 tons of ore mined. From 1904 until operation ceased in 1907 the plants were operated a total of 372 days. In 1906 the concentration and power plant was destroyed by fire but was rebuilt and put in operation the latter part of March, 1907, and operated until May 10 of that year, when the smelter and tramway terminal were destroyed by fire. These plants were rebuilt and began operation in May, 1908, and were operated until closed down in October of that year owing to financial difficulties occurring through the building of the Saratoga & Encampment Railroad, which connected the smelter at Encampment with Wolcott, Wyoming, on the main line of the Union Pacific Railroad. Previously all of the coke and supplies were hauled in and the finished product was hauled out to Wolcott, the nearest railroad point 47 miles distant.

The tramway connecting the Ferris Haggerty mine with the smelting works at Encampment is one of the longest aërial tramways in the world, its length being 16⅔ miles. It is operated in three sections, with a power plant at each section. There are 304 towers, tension and anchor stations, 884 buckets and 63 miles of wire rope. The track cables are 1¼ in. and 1 in. and the traction cables ⅞ and ¾ in. The cost of operation during the period was $0.9347 per ton of ore handled.

Twelve cars of ore shipped from the Doane-Rambler mine in 1901 averaged 40.7 per cent copper. and exhibits of ore from this mine at the St. Louis Exposition showed values of 900 lb., or 45 per cent, copper to the ton, these ores being bornite and chalcocite. This mine was bought to supplement the production of the Ferris Haggerty and has been developed to a depth of 665 ft. No ore has been taken out from the lower levels.

The Saratoga & Encampment Railroad runs directly south from Wolcott to Encampment, which is at the foot of the Continental Divide, at one of the lowest passes in the range. A survey has been made to connect this line with the Moffat Road at Steamboat Springs, a distance of sixty miles on a 2 per cent grade and a maximum altitude of 8500 feet.

The geological features of this district, many of which are interesting, are fully described in Professional Paper No. 25 by A. C. SPENCER of the Geological Survey, published in 1904.

An effort will be made by the purchasers to prove the value of the mines and have them operated if investigation will warrant the expenditures necessary. The smelter and concentrating plants at Encampment will be dismantled and the material sold, as concentration mills will be built at the mines and the concentrates transported to Encampment. Millsites and water rights are available at both the Ferris Haggerty and the Doane-Rambler mines.

California Mineral Production in 1918.

FLETCHER HAMILTON, the California State Mineralogist, has issued a preliminary statement of the mineral production of California which shows a wider variety of chemically valuable minerals than almost any other state in the Union and of a total value exceeded only by the large coal and iron producing states of the East. Gold decreased nearly $3,000,000 in value, while petroleum increased 5,000,000 barrels in quantity. Quicksilver dropped off about 2000 flasks, while manganese ores nearly doubled. Magnesite, however, dropped to 40 per cent of the previous year's total on account of the competition of the cheaper, iron-bearing magnesite from the state of Washington.

The estimated quantities and values for 1918 are:

Gold	$17,250,000
Silver (1,500,000 oz.)	1,450,000
Tungsten concentrates (2,300 tons)	3,000,000
Copper (49,000,000 lb.)	12,000,000
Lead (15,000,000 lb.)	1,100,000
Zinc (4,500,000 lb.)	375,000
Quicksilver (22,000 flasks)	2,310,000
Antimony, iron, molybdenum, platinum	90,000
Petroleum (100,000,000 bbl.)	123,000,000
Chromite (52,000 tons)	2,000,000
Manganese ores (25,000 tons)	1,125,000
Magnesite (90,000 tons)	900,000
Natural gas	3,000,000
Brick, cement, building stone, crushed rock, etc.	10,000,000
Miscellaneous "industrial" minerals	1,500,000
Salines (including borax, soda, salt, potash)	12,000,000
Total	$191,100,000

Company Reports.

Tomboy Gold Mines Co.—The annual report of this company for the year ended June 30 has just been issued. It shows that 151,000 tons of ore were milled at a cost of 70 cents per ton, yielding bullion worth $306,000 and concentrates worth $662,000 at a cost of 63 cents per ton. Tailings to the amount of 129,000 tons were cyanided at a cost of $1.08 per ton, yielding bullion worth $168,000. A marked shortage and inefficiency of labor has increased costs materially, and caused a reduction of ore reserves. Continuous tests were carried out from February to July with milling ore, so as to establish a reliable comparison between flotation and the present methods of treatment. The results confirmed the advantage of the flotation process, and it will make available large tonnages of developed low grade ore on the property. However, under the present condition of the labor and materials market, installation will be postponed.

The Coniagas Mines, Ltd.—The report for the year ended Oct. 31, 1918, shows that the mine at Cobalt and the smelter at Thorold, Ontario, have been operating continually. The tonnage milled was 68,597, or an average of 3.38 tons per stamp-day. From this ore was shipped 530 tons of high-grade concentrate containing 1164 ounces per ton, and 867 tons of slime concentrates containing 245 ounces of silver per ton. Mill heads averaged 15.94 ounces per ton and the tailings were reduced from 3 ounces to 1.75 by the use of the Callow flotation plant, which superseded canvas tables and cyaniding. Mining and concentrating cost 33.87c. per ounce of silver recovered, smelting and marketing 7.98c., while the output was sold for 94.14c. The average cost per ounce of silver produced during the twelve preceding years has been 16.3c. Re-treatment of the sand tailings pile was begun in May and continued until November, during which time 22,000 tons of an average value of 3.5 ounces were treated.

Report of the Patent Committee to the National Research Council

THE Commissioner of Patents in 1917, with the approval of the Secretary of the Interior, requested the National Research Council to appoint a committee to investigate the Patent Office and patent system, with a view to increasing their effectiveness, and to consider what might be done to make the Patent Office more of a national institution and more vitally useful to the industrial life of the country.

Mr. Thomas Ewing, who is a member of the Patent Committee, was the Commissioner of Patents who took that action.

The National Research Council, complying with the request, appointed a Patent Committee, consisting of: Dr. William F. Durand, chairman; Drs. L. H. Baekeland and M. I. Pupin, scientists and inventors; Drs. R. A. Millikan and S. W. Stratton, scientists; Dr. Reid Hunt, physician; and Messrs. Frederick P. Fish, Thomas Ewing and Edwin J. Prindle, patent lawyers. On the departure of Dr. Durand for Europe, Dr. Baekeland was appointed Acting Chairman of the Committee.

Four Changes Recommended

The Committee has concluded to propose a program consisting of but four features, because it believes those features are of such fundamental importance that their enactment into law would strengthen the entire system and directly and indirectly establish it upon a new and much more advantageous footing before Congress and the public; and because with a simple program, presenting comparatively little opportunity for difference of opinion as to the desirability of the changes proposed, there would be a unanimity of opinion in support of it which could not be obtained if the program were more extended.

A Single Court of Patent Appeals

The first proposal is the establishment of a single Court of Patent Appeals that will have jurisdiction of appeals in patent cases from all the United States Districts Courts throughout the country, in place of the nine independent Circuit Courts of Appeals in which appellate jurisdiction is now vested.

The existence of nine appellate courts of concurrent jurisdiction in patent cases works serious hardships. While, theoretically, the law is the same in all of these courts, there has been an irresistible tendency to drift apart in the application of the law. It has even happened in a substantial number of cases that two of the appellate courts have taken a different view of one and the same patent.

Would Benefit Industry

It would be of the utmost value to those in the United States who are engaged in industry if the present confused condition could be corrected and a single tribunal devote itself to crystallizing the fundamentals of the patent law and to educating the courts throughout the land to uniformity in applying these principles in special cases.

A bill is suggested for the establishment of such a Court, which has been advocated for many years by the American Bar Association, and is No. 5011, of the House of Representatives, 65th Congress, 1st Sess. It provides for a court of seven members, which would sit in Washington, with a Chief Justice appointed for life by the President. The appointment of the Chief Justice for life is in order that there may be an element of continuity in the Court. The other Judges are to be selected by the Chief Justice of the United States Supreme Court from the various District and Circuit Judges throughout the land, and each is to sit on the Court of Patent Appeals for a period of six years, or longer, if reappointed.

The Patent Office a Separate Institution, Independent of the Department of the Interior

The second proposal is that the Patent Office be made a separate institution, independent of the Interior or any other department. The Patent Office was originally in the State Department, but, on the formation of the Interior Department in 1849, it was made a bureau of that Department and has been so ever since.

The Committee believes that to make the Patent Office an independent bureau would greatly increase the respect of the public and Congress and the courts for it, and would make it easier to procure enlarged appropriations and better salaries than under present conditions.

A copy of a proposed bill for making the Patent Office an independent bureau is annexed to the report and its enactment is recommended by the committee.

Increase in Force and Salaries of the Patent Office

The third proposal which the committee recommends is a substantial increase in the force and salaries of the Patent Office. The patents granted by the United States Patent Office are of less average probable validity than formerly, because the number of applications for patent and the field of search are constantly increasing, while the examining force for many years has been insufficiently large and has not been increased proportionately. The inducements are so unattractive that twenty-five per cent of the examining force has resigned within the past three years. The salaries of the Patent Office examiners have been increased only ten per cent since they were fixed in 1848, when they were approximately the same as those of members of Congress. At the time the salaries of the Examiners-in-Chief were fixed, they were the same as those of Federal District Judges.

Low Salaries Paid

During the past seventy years, the compensation for technical service in almost all other directions has been increased very largely.

Congress, in creating new positions, is willing to pay technical men salaries more nearly approximating the usual compensation of such men in private service, but, having started a position at a given salary, is very loth to increase the salary. A Principal Examiner, to pass the entrance examination for the Patent Office, must himself have an education equivalent to that of a college graduate, and yet his salary is so low ($2,700 a year) that it is practically impossible for him to give

his own sons a college education. The committee believes that salaries should be paid to the examiners proportionate to those paid for equally high technical work in other departments created recently.

Recently there have been two or three decisions in which the courts have taken a more liberal attitude, holding in effect that where an invention has been used by an infringer a reasonable royalty may be awarded to the patentee based on a mere estimation or on opinion evidence, even though no exact computation can be made.

An amendment has been proposed to Section 4921, the Revised Statutes of the United States, reading as follows:

> "If proof is not offered or, in the absence of adequate proof of the amount that should be awarded as damages or profits, the court, on due proceedings had, may adjudge and decree to the owner payment of a reasonable royalty or other form of general damages."

This proposed amendment would enable the patentee in all suits where the patent has been found valid and infringed to recover at least a reasonable royalty, and would provide a money recovery in the great majority of patent suits where no recovery would otherwise be possible.

Research Vacancies in the University of Illinois

THE University of Illinois announces that at the close of the current academic year there will be eight vacancies to be filled in the research graduate assistantships maintained by the Engineering Experiment Station of the university. In addition there are available two research graduate assistantships in gas engineering, which are supported by the Illinois Gas Association. These assistantships, for each of which there is an annual stipend of $500 and freedom from all fees except the matriculation and diploma fees, are open to graduates of approved American and foreign universities and technical schools who are prepared to undertake graduate study in engineering, physics, or applied chemistry.

Appointments are made and must be accepted for two consecutive collegiate years, at the expiration of which period, if all requirements have been met, the degree of master of science will be conferred. Not more than half of the time of a research graduate assistant is required in connection with the work of the department to which he is assigned, the remainder being available for graduate study.

Nominations to these positions, accompanied by assignments to special departments of the Engineering Experiment Station, are made from applications received by the director of the station each year not later than March 1. The nominations are made by the executive staff of the station, subject to the approval of the president of the university. Nominations are based upon the character, scholastic attainments and promise of success in the principal line of study or research to which the candidate proposes to devote himself.

Preference is given those applicants who have had some practical engineering experience following the completion of their undergraduate work. Appointments are made in the spring, and they become effective the following September.

The Engineering Experiment Station, an organization within the College of Engineering, was established in 1903 for the purpose of conducting investigations in the various branches of engineering and for the study of problems of importance to engineers and to the manufacturing and industrial interests of the State of Illinois. Research work and graduate study may be undertaken in architecture, architectural engineering, ceramic engineering, chemistry, civil engineering, electrical engineering, mechanical engineering, mining engineering, municipal and sanitary engineering, physics, railway engineering, and theoretical and applied mechanics.

Additional information may be obtained by addressing the director, Engineering Experiment Station, University of Illinois, Urbana, Illinois.

Secretary Lane Seeks Survey of Power Resources

Secretary Lane of the Interior Department has sent to Congress requests for two appropriations for special investigations and report on the power supply. One of these is a request for an appropriation of $50,000 for a survey of the power resources all over the United States. This proposed appropriation is embodied in the Sundry Civil Bill, hearings on which are now being held before the subcommittee of the House Committee on Appropriations. If approved, the work would be done by the Geological Survey. The other request is for an appropriation of $200,000 for a report on the power supply for the industrial region of the northern Atlantic seaboard, extending in general from Boston to Washington. If approved, this work would be done by the Geological Survey and the Bureau of Mines in co-operation. The request for the $200,000 appropriation has been approved by the Secretary of the Treasury, and has been forwarded to Mr. Swagar Sherley, chairman of the House Committee on Appropriations.

Deadlock on Water Power Legislation

The water-power conferees of the Senate and House of Representatives have held another meeting lasting for three and one-half hours, and are again deadlocked upon the same question which has prevented the passage of a water-power bill for five years, namely, the question of the charge to be made.

The Washington representative of CHEMICAL & METALLURGICAL ENGINEERING reports that Senators insist that no charge shall be made for the use of water, on constitutional grounds, while the House conferees are insisting that the language of the House bill shall be used, which would give to a proposed Federal Power Commission the right to make a charge for water.

The attitude of those in Washington who are familiar with this proposed legislation is that the charge which would be made is so small in comparison with the benefits to be derived that the Senate could well recede from its position. The conferees adjourned subject to the call of the chairman, and will try to hold another meeting Monday.

Chemical Warfare—A New Weapon

Novel Views on the Future of Gas Warfare Expressed by Brigadier General Amos A. Fries—Lower Death Rate From Gas Casualties Than From All Others—The "Humanity" and Effectiveness of Gas Warfare

By Ellwood Hendrick

In August, 1917, Brigadier General Amos A. Fries, of the U. S. Engineers, was appointed to command the chemical warfare service of our Army in action. He has lately returned to the United States, and it was the privilege of the writer to spend a couple of hours in discussion with him concerning gas warfare and the chemical wing of the service. Gen. Fries has been awarded the rank of Commander of the Legion of Honor by the French Government.

The opinion seems to prevail generally that the use of poison gas, launched in breach of faith by the German High Command, has reached an end for all time; that by general agreement in convention it will no longer be endured, and that it is to be classed with the many practices of violence and debauchery of which the German army was guilty.

This is not in accord with General Fries' opinion. The Allied troops used chemical warfare in constantly increasing measure because it is an effective weapon. On the other hand atrocities were neither practiced, encouraged, nor permitted. It is General Fries' belief that the use of other chemicals besides shot and shell, having been introduced into the art of war, can never be eliminated. The situation is somewhat like that when gunpowder was introduced, and universally frowned upon as unfair and unsportsmanlike; yet it has endured.

Why Chemical Warfare Will Not Be Permanently Suppressed

The principal reasons why gas and chemical warfare is unlikely to be permanently suppressed are because

It is the most humane method of fighting, if both sides are prepared for it, while

It is the most deadly of all methods to the side that is unprepared.

The "humanity" of poison gas we shall consider shortly; the first point is that the army that is prepared against it is unlikely to be severely injured, while that which is unprepared is almost certain to meet defeat in an attack. Now, wars are usually caused by the breach of agreements, and it is seldom that a nation at war trusts its enemy. And if the enemy by the use of chemical warfare is able to win, then its opponent will have to be prepared. War has not yet reached the stage of the code duello, whereby an impartial umpire may step in and declare the fight off if unfair practices are employed. So the only safety against defeat is to be prepared against chemical attack. This takes a long time and peculiar training, while most wars are of shorter duration than that with which we have lately been engaged. The old military axiom of safety in preparedness still holds good. When the Germans launched their first clouds of chlorine the road to the Channel ports was open to them. The trouble was, as usual, that Fritz was a little slow in his thinking, and he missed his chance. The Allies obtained time enough, by a miracle of industry on the part of British and French women, to make preparations, and then, after gas warfare was started, the Allies thought faster than the Germans, and finally beat them at their own game.

Now in regard to the "humanity" of gas warfare, it should be remembered that the American troops were originally not prepared against it. Our men were saved by the British. No fewer than 700,000 British gas masks were furnished to us before the American masks arrived. Our first gas officers and troops were trained by the British, and so well trained withal that they avoided accidents. It was only by means of this help that we may be said to have been partially ready. Despite this defect in preparation the following figures are illuminating. Of our total casualties in battle about 30 per cent arose from gas, leaving 70 per cent caused by all other forms of attack such as bullets, shrapnel, machine guns, high explosive shells, etc.

Gas Caused Only 5 Per Cent of Deaths

But while the gas wounded equalled 30 per cent of our casualties, deaths from gas were only 5 per cent of the total deaths. In other words, of each 100 wounded with gas 3 to 4 die, while of each 100 wounded with bullets, high explosive, etc., 20 to 25 die. Deaths from pneumonia and other lung complications following gassing are included in the 3 to 4 per cent given. Of the total casualties from other causes, 20 to 25 per cent died, and this does not include the men who are maimed. We have more than 3000 men who have lost either a leg or an arm, not to count those who have been blinded. There is no authenticated case of permanent blindness from gas. The U. S. authorities in the very beginning prescribed the use of gas in all shells from 3 to 8 in. in diameter, and finally, last summer, the list was made to include all shells up to 9½ inches.

Against savages or semi-civilized tribes gas warfare may be made as humane as is desired. Lachrymator or tear gas will cause temporary blindness so that enemy troops may be easily captured, though within a few hours the prisoners have their sight completely restored, and are not physically injured otherwise.

The training of gas troops is of primary importance. It is required of them that they use their noses to sniff out the first sign of gases. Sensitiveness to this grows as the men remain in the service. The men must know the hazards, and yet they must not be frightened so as to make them susceptible to panic. Protection must be adequate, but not a burden. Better a little hazard than discomfort which men cannot endure.

The entire system of defense needed to be changed with the advent of mustard (dichlorethylsulphide). Theretofore with chlorine, phosgene, diphosgene (trichlormethylchlorformate, etc., the attacks were intense but short lived. Mustard, however, which boils at about 217 deg. C., remains in place, and in cold, still weather lasts more than a week after it has been spilled upon the earth. This requires a more comfortable protection and the necessity of moving troops from gassed to free areas. Very fortunately this necessary change in tactics was synchronous with the change from trench warfare to an elastic front.

Gas troops also are drilled in the use of Livens projectors and bombs, and Stokes mortars, both of which are British contributions. The Livens projectors are 8-in. drawn steel tubes, either 2 ft. 9 in. or 48 in. in length. These are loaded with loosely fitting bombs 8 in. in diameter and about 14 in. long. They are fired simultaneously in groups of 50 to 2500. The Stokes mortar is a 4-in. heavy tube, by means of which 25 to 40 bombs, fitted with fuses to break them open, may be fired per minute.

Need for Chemists as Officers

Practice also shows the need of 3 to 5 chemical warfare officers on the staff of each commanding general to augment the artillery, as well as gas troops to follow up the infantry. It is also desirable that of the Chemical Warfare Division in the field, at least 25 to 30 per cent of the officers be sound chemists.

Laboratories are absolutely essential, and these must keep in close touch with the field. Leading authorities are of the opinion that the greatest hindrance to the work of the National Research Laboratory in Washington was its inability to keep in touch adequately with the fighting line. The vast number of reports which were lost, including thousands of pages of supremely valuable data which never arrived, made the situation worse. There were sent from France during the six months 360 reports, and of these a great many have not been found to this day. Defective communications were among our most expensive troubles.

Laboratories should be recognized as an intimate part of the fighting machine, inasmuch as only by this means can the constantly changing problems of this scientific method of warfare be met. The lack of enough and of very capably manned laboratories in chemical warfare is no less than an invitation to defeat. With proper laboratory co-operation, however, chemical warfare offers the greatest range for ingenuity to both officers and men in the field and on the staff.

On the other hand it is of signal importance that chemical warfare be under military guidance, because purely laboratory methods give wrong and harmful results. An instance of this may be cited in the case of vincennite, a French preparation of hydrocyanic acid which, while remarkably toxic upon dogs, was little more than useless in the field. The British succeeded earlier than the French in achieving active co-operation between their military and chemical staffs, and they benefited accordingly, contributed more, and made fewer errors. As soon as the French obtained this co-ordination their progress was immensely accelerated. Errors of the following type are typical of laboratory work without military communication and control: too tight elastics in masks, too long rubber mouthpieces, the wrong use of such a gas as vincennite, as stated above, etc.

The first American gas troops were trained by the British for three weeks. The first independent American gas attack was made along the front of the Rainbow Division in April, 1918, and so well did the troops acquit themselves that the regiment received the decoration of the Legion of Honor, and 26 Croix de Guerre were distributed among officers and men.

Gas Troops of Incalculable Value

As the art progressed it became part of every battle plan to answer the questions, "Where can we use gas?" and "Where can we use smoke?" Then as the battle proceeded the gas troops followed the infantry, and became of almost incalculable value in breaking up machine-gun nests. The method came from the collaboration of various branches of the Chemical Warfare Service, wherein Stokes mortar bombs were employed, containing thermit and white phosphorus. They were remarkably effective. One single shot brought out 77 boches, hands up and crying "Kamerad!" This is but an incident of the ingenuity of the chemical division when it is well organized. Thermit has its faults; it cools very quickly, but the phosphorus gave it a bewildering quality. Whenever a smoke screen was needed the chemical troops were at hand to provide it. Against a massed attack a few bombs of phosgene and diphosgene were very discouraging unless the men were adequately protected, for phosgene is quick in action and gives 20 per cent fatalities. It is, however, quickly dissipated. As the war neared its end our troops were able to protect themselves against a gas attack within fifteen seconds after the first flash.

Size of American Chemical Division

Another important service developed by the gas troops was the loading of Livens bombs filled with 30 lb. of TNT, of which they fired twenty or more at a time. As these bombs did not bury themselves in the earth they completely swept the area covered by them of every living thing. More than 1000 of these were made in the field in France and put over, and 2000 more were in the making. Here also screens of smoke were often followed by screens of gas. Again, the artillery would administer the doses while the chemical officers would select the medicine. So useful were these gas troops that by the spring of 1919 there would have been no fewer than 18,000 Americans in chemical service abroad.

Not only the need of laboratories but the absolute necessity for them has been mentioned already. The Germans shot their first mustard in July, 1917, and the Allies came back with it eleven months later. Also in October, 1917, the development of the gas mask for long-time wear was begun. The final American type, which was by far the best one made, was a modification of the French Tissot mask, which permits breathing naturally through the nostrils, and in which the eyepieces are kept clear.

Another result of the research laboratory while under Colonel Bacon was the discovery that boiled linseed oil had a marked influence in retarding mustard burns.

Further research brought out the fact that this was due to metallic salts dissolved in it. It resulted in what was called "sag paste," a mixture of zinc stearate and vegetable oil, about half and half, which made an effective unguent. It did not prevent burns, but it took about six times the concentration necessary to cause burns without it.

Camouflage Gases Prepared

Camouflage gases were prepared to disconcert the enemy smellers. These were nearing completion at the time of the armistice. They made it impossible for Fritz to know what he was getting.

Other contributions in research were a saving of from one to two million dollars in specifications for camouflage paints, a fire extinguisher for aëroplanes, a new aëroplane glue, analyses of gases from German shells, the testing of masks, fabrics and smoke canisters or boxes attached to masks, because, while orders were given for each man to record the time he used his mask in gassed area, it did not work in practice. The men would not keep the records as prescribed while they were busy fighting.

Research both at home and in England resulted in technology superior to that of the Germans; indeed, toward the end of the war, the Germans' leading spy was operating in France and elsewhere to discover how mustard could be made in such quantity. The Germans at no time were able to produce over six tons of it daily. This superiority was evident as early as 1917, when rumors were rife that a German professor of humane tendencies was urging upon the International Red Cross the need of coming to a conclusion with the war, on the ground that by the spring of 1918 the Germans would launch such a fatal poison that it would produce nothing less than a holocaust among the Allies. It was suspected that this was an exponent of German fear rather than of German humanity, so word was sent back that the Allies hadn't really begun to fight with gas yet, and had no thought of quitting.

Troubles in Establishing Chemical Warfare

As for the troubles which had to be met in establishing chemical warfare their name was legion. The first requirement was personnel, and there wasn't any. "State your requirements," said headquarters, and nobody knew what they were. Personnel was, however, finally assembled, and among the splendid corps of men the following are worthy of special mention:

Colonel E. J. Atkinson (West Point '08), of the First Gas Regiment, which went over as the Thirtieth Engineers.

Colonel Richmond Mayo Smith (of Plimpton Press, Norwood, Mass., and N. Y.), in charge of supplies.

Lieutenant-Colonel Byron C. Goss, in charge of gas warfare at the front, a wonderful instructor in the subject.

Colonel G. N. Lewis (University of California), whose military sense was equal to his quick and profound chemical understanding.

Major Carl Connell (New York University), who developed the final type of mask.

Major Zanetti (Columbia University), chief liaison officer, with the French.

Major Joel H. Hildebrand (Professor at University of California), in charge of experimental field and officers' gas school.

Colonel Raymond M. Bacon (Director of Mellon Institute), in charge of research.

Major Keyes (Boston Tech.), in charge of research laboratory in Paris.

Captain Boothby, who taught mask drill.

And many others.

There was also Colonel Harrison of the British Army, who was a tower of strength in getting gas masks from England to our men, by cutting red tape and coming to the rescue. He was engaged in pharmaceutical chemistry in London, enlisted as a private at the age of 46, and died last year as a Brigadier General.

It took two months from the time munitions left the United States to reach the army at the front. While this was not always the case, it was necessary to count upon such a lapse of time. And communications, so far as forwarding reports, etc., were concerned, were no less than desperate.

Gas Inviting for Police Work, Because Effective Without Involving Fatalities

In conclusion, while conventions may agree to forbid the practice of chemical warfare, it is, as we have said, a remarkable weapon of offense. Its employment places an army at so great an advantage over an unprepared enemy that it will be difficult to trust nations to forego its use. It is exceedingly inviting for police work, because it may be made effective without involving fatal casualties or maiming. The question, therefore, must be met whether future wars shall be controlled or not. If they are to be fought under international supervision, under rules akin to an international code duello—in which event it would seem that swords alone should be the proper weapon—then we have every reason to hope for the best, so long as the supervisors do not get to fighting among themselves. On the other hand, it may be that scientific warfare will be recognized, and allowed to develop until war itself shall be prohibited by some working agreement owing to its destruction of the world's accumulated property. Half-way measures and compromises will not meet the situation. And if there is to be an international police then chemical munitions will be needed to avoid unnecessary loss of life.

War Trade Board Rulings

Export Licenses for Shipment to Switzerland—Licenses will be issued freely for the exportation of the following commodities to Switzerland, if applications are otherwise in order:

Chemical products for pharmaceutical use, including chromic acid, hydrobromic acid, salicylic acid, arsenical salts for medicinal use, sodium bromide, sodium nitroprusside, silver nitrate, amidopyrin, betanaphthol, eucaine, paraldehyde, phenacetin, aconite and preparations of alkaloids of aconite, opium and preparations of alkaloids of opium; china clay; iron and steel (except high-speed steel); essential oils; all commodities when value of shipment is less than $200.—W. T. B. R. 542 and 583.

Wolfram:—Licenses for importation of wolfram will now be issued freely.—W. T. B. R. 565.

Electrolytic Deposition of Zinc

Preparation of Cell Liquor From Fumes Collected as a Sludge in the Acid Chambers—Details of the Theoretical and Applied Electrochemistry Involved, Together With Charts and Data

By H. E. BROUGHTON

THE ore smelted by the Ducktown Sulphur, Copper & Iron Co., of Isabella, Tenn., contains slightly more zinc than copper and in the semi-pyritic method of smelting in use by this company all this zinc was lost, being carried away as fume and in the slag. The fume produced is a gray to white powder and contains upwards of 40 per cent zinc, chiefly in the form of sulphides, though the oxide and sulphate are also present.

As this fume is an impalpable powder, it is carried along with the gases entering the acid chamber and in the long, slow passage through these chambers it settles out and all the zinc compounds are converted into sulphates. The zinc sulphate, together with what other substances are carried along by the gas, and the lead sulphate formed by the corrosion of the lead chambers combine to form a heavy, white mud which collects in the pan of the chambers and which is quite insoluble in the chamber acid. The mud or sludge thus formed builds up quite rapidly and must be cleared out of the chambers frequently.

With the idea of recovering the zinc values from this mud or sludge, the company began an investigation of the possibility of using an electrolytic process. The first attempts were highly unsatisfactory. The sludge was thoroughly agitated with sufficient water to dissolve out all the zinc sulphate; the agitation was then stopped and the lead sulphate and insoluble substances allowed to settle. The clear solution was decanted and electrolyzed, using insoluble lead anodes and aluminium cathodes. The acidity of this solution ran about 13 per cent sulphuric acid and there were present all sorts of elements more electro-negative than zinc.

After it had been proved that it would be impossible to electrolyze the solution decanted from the leaching tanks without an initial purification process, a thorough investigation of the problem was begun and a process developed which would yield a practically pure zinc sulphate solution.

ELECTROLYTIC ZINC PLANT OF THE DUCKTOWN SULPHUR, COPPER & IRON CO., LTD., AT ISABELLA, TENNESSEE

An average analysis of the sludge will run as follows:

	Per Cent.
Zinc sulphate ($ZnSO_4$)	51.6
Ferric sulphate ($Fe_2(SO_4)_3$)	0.1
Sulphuric acid (H_2SO_4)	13.7
Lead sulphate ($PbSO_4$)	14.6
Copper sulphate ($CuSO_4$)	0.4
Cadmium sulphate ($CdSO_4$)	0.6
Moisture	16.0
Residue (SiO_2, S, C)	3.0
	100.0

The decant from the leaching tanks will obviously contain all these compounds except the lead sulphate and the residue. The purification process as finally perfected consisted in two main steps: First, the neutralization of the acid and the precipitation of the ferric iron; and second, the elimination of the metals more electro-negative than zinc.

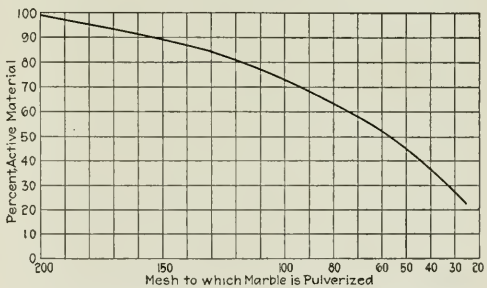


FIG. 1. CURVE SHOWING RELATION BETWEEN FINENESS OF GRINDING AND PERCENTAGE OF MATERIAL ACTIVE IN NEUTRALIZATION

Before taking up the purification process, it might be well to explain the method of handling the marble used in neutralization. From nearby marble works a waste product was procured very cheaply. This marble analyzed:

	Per Cent.
$CaCO_3$	97.28
Fe_2O_3	0.17
Al_2O_3	0.34
SiO_2	1.94
Undetermined	0.27
Total	100.00

This material was in the form of small chips about the size of rice grains and contained no dust. It made an ideal feed to the pulverizing mill and, being bone dry, could be put through very rapidly. The discharge from the mill showed by screen analysis that about 83 per cent would go through a 100 mesh and 100 per

cent through a 30 mesh. The curve in Fig. 1 shows the per cent of active material available for neutralization in this process.

Purification Process

The first step in the purification of the decanted solution was the elimination of the sulphuric acid and the ferric sulphate. This was accomplished in two steps: First, the neutralizing of the acid and the consequent precipitation of the $Fe(OH)_3$ from the neutral solution and second, the filtering of the pulp resulting from the first step.

Pulverized marble was used to neutralize the sulphuric acid and was added to the solution in a large mechanically-stirred tank. Steam coils heated the solution to about 60 deg. C., and the action taking place may be expressed as

$$CaCO_3 + H_2SO_4 = CaSO_4 + H_2O + CO_2. \quad (1)$$

The reaction is complete and the operation simple. As the $CaCO_3$ will cease to act as soon as the solution is neutral, there is no danger of carrying the reaction too far and making the solution alkaline. This was a decided advantage, as the zinc would be precipitated even from a slightly alkaline solution.

Loss in Zinc Small

The $CaSO_4$ thus formed was fairly insoluble and was easily eliminated on a filter. By a careful washing of the filter cake, the loss in zinc was very small. We have found the Oliver continuous filter to be a most excellent filter for this work, the loss of zinc in the filter cake being less than 5 per cent, while the wash water necessary to accomplish this result was too small to lower materially the concentration of zinc in the filtrate. The only drawback to this process was the frequent cleaning necessitated by the slight precipitation of $CaSO_4$ in the pores of the filter cloth as the filtrate cools in passing through. Hot water and stiff brushes, however, applied daily kept the pores nicely open. An occasional bath with hot dilute muriatic acid was found beneficial.

The electro-potential of metallic zinc against a normal solution of its cathion (32.5 grams of zinc per liter) is +0.49 volts, and any metallic element which has a lower potential than this under the same conditions of concentration should be replaced in solution by a zinc ion or ions, when the solution containing such metals is brought into contact with metallic zinc. A slightly acid solution accelerates the reaction.

Thus, copper in a copper sulphate solution will be completely eliminated from solution as a spongy deposit on a piece of zinc according to the reaction expressed as

$$2Cu^{++} + Zn_2 \rightarrow Cu_2 + 2Zn^{++} \quad (2)$$

Since any metal capable of forming an insoluble sulphate is automatically eliminated from the solution and left as a residue in the leaching tanks, all the first group and 2B group metals are thus taken care of. This leaves copper, cadmium and bismuth, and the slight amount of iron brought in with the acid used to accelerate the action, to be precipitated on zinc.

The following table gives the electro-potentials of these elements against a normal solution of their cathions and the difference in potential between each element and zinc under the same conditions:

Element	Potential in Volts	Potential of Zinc	Difference in Potential, Volts
Copper	−0.61	+0.49	1.10
Cadmium	+0.14	+0.49	0.35
Bismuth	−0.67	+0.49	1.16
Iron	+0.06	+0.49	0.43

These potentials are true only for the pure metal against a pure normal solution of its cathion. However, it provides a basis for reasoning, and in actual practice it is found that the reaction does occur quantitatively and quite rapidly.

In the practical application of the principle, the zinc mass must be of large surface and the contact with the solution positive and of as long duration as is practical. The concentration of zinc ions is naturally enormously larger than the concentration of the other metals, and for this reason the actual voltage relations expressed above for ideal conditions probably do not obtain, but sufficient potential difference does exist to procure the desired results.

Time Element Important

It has been found experimentally that, under the conditions imposed by the problem, a concentration of about 0.2 per cent acid gives the best results with the least harm: that is, an average of 0.2 per cent H_2SO_4 in the whole process. Now in the practical method of handling this process, the time element is quite important and the amount of acid added to the neutral filtrate from the first step should be proportioned to give an average of 0.2 per cent H_2SO_4 throughout the time of contact with the zinc mass. This procedure should be regulated to give a maximum of 0.1 per cent H_2SO_4 in the resulting purified solution, or as much less as is practical.

In practice, the above reactions were carried out in two tanks three feet in diameter by seven feet high, operated on the Pachucca principle; the mass of zinc, in the form of broken sheets, nodules and odds and ends from the stripping room, was supported about nine inches above the bottom of the tank on a grating and extended up to within a foot of the top of the tank. A lead pipe extended down through this mass to below the grating. A small air pipe was led down and turned up inside the lead pipe and the air admitted here caused a rapid and thorough circulation of all solution in the tank over the zinc mass. It was feared at first that this method would not work after the zinc mass had become coated with the mossy deposit of the metals it replaced in solution. These fears were groundless, however, as two tanks working in series handled continuously and efficiently the work imposed upon them.

The copper in solution was completely removed in a very short time and the slight amount of bismuth present was also easily eliminated, but the cadmium was a trying proposition, and so far it has been found impossible in these tanks to eliminate it absolutely, no matter how long a time of contact is maintained or what concentration of acid is used.

The precipitated cadmium will redissolve appreciably if allowed to stand in an even faintly acid solution and, since this element is the greatest enemy to a pure zinc product, it was found best to filter all the solution as fast as it left the precipitating tanks, rather than allow the small amounts of solids to settle and then decant a major portion of the solution, as would seem the natural

procedure. The solution from these tanks, after being filtered, was ready for electrolysis.

Electrodeposition of Zinc

There is a constant peculiar to each element known as the electro-chemical-equivalent. The derivation of and laws pertaining to these constants are perfectly familiar to the chemical and metallurgical world, and too much profound thought has been given to the subject for this article to add anything further. Suffice it to say that for the element zinc the electro-chemical-equivalent is 1.2211 grams of zinc per ampere hour. Then, theoretically, for every ampere hour of work applied to a suitable solution containing any zinc salt in any concentration, we should recover 1.2211 grams of metallic zinc on the cathode. This constant expressed in pounds of zinc per 1,000 ampere hours is 2.69.

Suppose in the cell we use an average current of 10,000 amperes per day of twenty-four hours, we should expect to recover

$$\frac{10{,}000 \times 24 \times 2.69}{1000} = 646 \text{ pounds of zinc per day.}$$

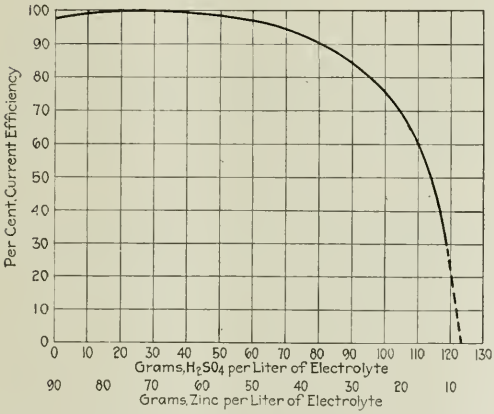


FIG. 2. CURVE REPRESENTING AVERAGE OF A LARGE NUMBER OF POINTS ALL MEASURED UNDER THE SAME CONDITIONS OF TEMPERATURE, CURRENT DENSITY AND ELECTRODES, IN A SOLUTION CONTAINING ONLY $ZnSO_4$ AND H_2SO_4

If the electrolytic plant operated at 100 per cent current efficiency, this obviously would be the yield. Unfortunately, it is impossible in practice to reach 100 per cent efficiency and a term, "current efficiency," has come into use to express the ratio of zinc produced to the theoretical yield. The curve shown in Fig. 2 indicates the current efficiency of a certain zinc sulphate solution when electrolyzed. This curve will be discussed later.

A solution of any zinc salt forms an electrolyte. The electrical resistance of all electrolytes varies with the salt concentration and with different salts. Thus the electrical resistance of a zinc sulphate solution of, say, 1 N concentration differs from the resistance of a 1 N solution of zinc chloride; and, further, a 1 N solution of sodium sulphate is still different in electrical resistance. Finally, the electrical resistance of a 1 N zinc sulphate solution is quite different from the resistance of a 5 N, or a 1/100 N solution. The laws governing this variation in electrical resistance have been very carefully studied by Ostwald, Kohlrausch and A. A. Noyes.

The researches have shown the existence of certain relations between the concentration of a salt in solution and the electrical resistance of that solution; and further, they have classified the various salts into groups in which the effect on electrical resistance of the solution containing any one member of the group in solution is the same. As a matter of fact, the change in resistance of the electrolyte with the change of salt or concentration is an effect and not a cause.

The cause lies, first, in the fact that it is the individual ion that carries the current through the electrolyte and therefore an increase in concentration will cause an increase in the amount of current carried at a given e.m.f., or a decrease in resistance; and, second, in the speed at which the ion travels through the solution or, as it is called, the speed of migration of the ion. Thus a fast traveling ion will show in solution a greater amount of current transported through the electrolyte (that is, a decrease in resistance) than a slower moving ion if both are present in equivalent concentration.

Since, therefore, the number of ions available and the speed at which each travels determine the electrical resistance of the electrolyte, it is evident that a concentrated solution will be of the lowest resistance provided the per cent ionization of the salt in solution is high. Thus a third factor enters, namely, the per cent ionization of the salt. For a salt may be very soluble, so that its concentration in solution is high, and yet the concentration of ions, or current carriers, may be very low, due to the small per cent of the salt ionized.

When a zinc sulphate solution is electrolyzed the chemical reaction taking place may be expressed somewhat as follows:

$$ZnSO_4 + 2\oplus + 2H_2O = 2H_2SO_4 + O_2(\text{gas}) + Zn_2 \quad (3)$$

While this equation is not strictly true, it serves to express the reaction in a simplified form, indicating the electrical charges of 193,000 coulombs of electricity. If 100 per cent recovery were possible, oxygen gas and metallic zinc would be the only two products of electrolysis. As the acid formed by electrolysis increases, the number of hydrogen ions from the dissociated acid increases, and as the hydrogen ion in solution acts as a metal and therefore travels toward the cathode, some of the hydrogen ions are certain to strike the cathode, give up their electrical charge and be deposited out as hydrogen gas. The amount of hydrogen gas thus formed represents a direct loss, and the current efficiency based on zinc recovery is therefore decreased in direct proportion to the amount of hydrogen involved.

It has been determined that the velocity with which the hydrogen ion migrates toward the cathode, in an electrolyte under an electrolytic pressure of 1 volt, is 0.0032 centimeter per second, while under the same conditions the velocity of the zinc ion is 0.00048 centimeter per second, or the velocity of the hydrogen ion is 6.66 times the velocity of the zinc ion. This difference in speed would mean that one hydrogen ion could travel 6.66 times as far as one zinc ion in a given time, or equally as far as 6.66 zinc ions.

Zinc is a bivalent metal, while hydrogen is univalent;

then from the reaction equation (3), two hydrogen ions are formed every time one zinc ion is plated out of solution (assuming 100 per cent ionization of the acid formed).

Since it is the ionic movement which forms the so-called flow of electrical energy through the solution, it is evident that the greater the number of hyrogen ions in solution the faster will the electrical energy flow through the solution; or, in other words, the lower will be the resistance of the solution.

It is obvious that in the electrolysis of a zinc sulphate solution the SO_4 ion is unaffected and its concentration therefore will remain constant. Now as the concentration of the hydrogen ion increases, due to the formation of metallic zinc on the cathode by the reaction equation (3), a steadily increasing amount of un-

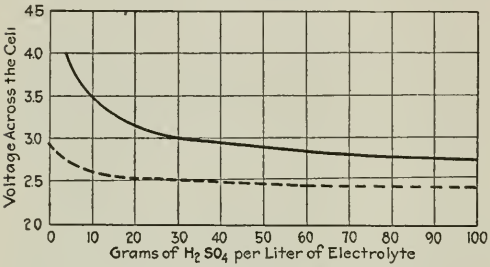


FIG. 3. VARIATION IN VOLTAGE WITH CHANGE IN ACIDITY

dissociated H_2SO_4 will be formed and therefore all the hydrogen ions released are not available as energy carriers. The concentration of $ZnSO_4$ will directly affect this result, for by the law of mass action $\frac{(H_2) \times (SO_4)}{(H_2SO_4)}$ = a constant and due to the high concentration of $ZnSO_4$ there will be present a large excess of SO_4 ions over those required by the hydrogen ions. Or in other words, in order to fulfill the conditions expressed by the law of mass action, a much greater percentage of the hydrogen will be present as undissociated H_2SO_4 than if there were no $ZnSO_4$ present in the solution.

So the net result in the conductivity of the electrolyte is considerably less than might be anticipated from our study of the relationship between the migration velocities of the hydrogen and zinc ions.

If the zinc sulphate and the sulphuric acid in the electrolyte were completely ionized, however, then the conductivity of the electrolyte would increase rapidly with increase in acidity and more and more hydrogen gas would be plated out as the concentration of the hydrogen ion increased. To carry this result further, when the concentration of hydrogen ion equals 1/6.66, that of the zinc ion, then the number of hydrogen ions coming in contact with the cathode per second would be equal to the number of zinc ions reaching the cathode; and since the current efficiency is the ratio of zinc recovered to zinc theoretically deposited by a given current, this efficiency will be only 50 per cent at this point. Since, however, a varying proportion of the hydrogen ions are suppressed by the high concentration of the SO_4 ions, this relation is not strictly true in practice.

Based on actual measurements under as nearly perfect working conditions as it was possible to obtain, the curve in Fig. 2 represents the relation between acidity of the electrolyte and the current efficiency. It should be noted that the current density at which the points on this curve were measured is 17 amperes per square foot, and the actual current density used in operating the plant varied between this figure and 20 amperes per square foot. The current density is the total current per cathode divided by the area of the cathode exposed to the electrolytic action. This so-called current density is chiefly important as a means of classifying the various effects that the other variables, as, for instance, acidity, impurities, etc., have on the efficiency of recovery; for, as a general rule, the lower the current density under any conditions the higher will be the efficiency. The best working conditions seem to be about 20 amperes per square foot, or a trifle under.

Since for every gram equivalent of zinc plated out, 98/2, or 49, grams of H_2SO_4 are formed, it is evident that very nearly one and one-half grams of acid are formed per gram of zinc plated out. Thus, the derivation of the upper scale of abscissa measurement becomes evident.

This curve represents ideal conditions, both chemically and electrically, and in practice it was never possible to obtain better than 70 per cent current efficiency over any given period of time. However, the curve shows what is possible and undoubtedly could be approached more closely by a more careful refinement of the process.

Voltage Requirements

The electromotive force required to electrolyze a zinc sulphate solution is made up of two factors—first, the dissociation voltage of the salt, and second, the resistance of the path through the electrolyte. The dissociation voltage for zinc sulphate is about 2.35 volts at 15 deg. C. for the concentrated solution used. This value is calculated from the heat of formation in calories per mole of cathion and varies with the temperature of the solution. The errors entering into the calculation due to inexact measurements render the final result rather uncertain, but from a good many measurements the value of 2.35 volts seems to be fairly accurate.

From the above discussion on the variation in conductivity of electrolyte due to change of acidity, it will be seen that since the voltage drop through the solution is equal to the current flowing in amperes multiplied by the resistance of the path in ohms, the potential difference across the electrodes will vary with the acidity of the solution. Therefore the voltage across the electrodes is equal to (2.35 + a variable) volts. And since this variable reaches its maximum value when the acidity is zero, the voltage across the electrodes should decrease as the electrolysis continues, and this is found to be the case. The accompanying curves in Fig. 3 show the variation in voltage with change in acidity for a certain set of conditions. And while the variation of these conditions would change the numerical value of the ordinates against which this curve is plotted, the general characteristics of the curve would be the same.

The variation in dissociation voltage mentioned above due to temperature change is usually expressed as a function of the absolute temperature by the ratio $\frac{\Delta E}{\Delta T}$

where ΔE is the change in electromotive force due to a change in the absolute temperature, ΔT. The value of this fraction for the range of temperatures permissible in electrolyzing a zinc sulphate solution is

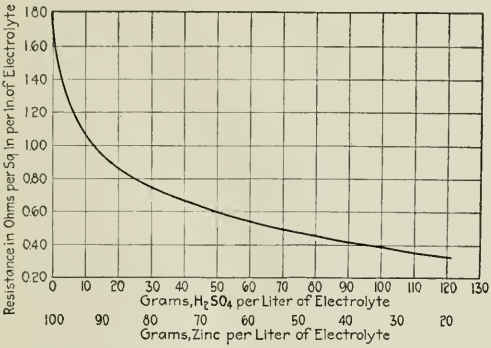


FIG. 4. ELECTRICAL RESISTANCE OF ELECTROLYTE MEASURED BETWEEN C.P. ZINC ELECTRODES

slight, and for all practical purposes the value of 2.35 volts is correct for a pure zinc sulphate solution of 2 N or stronger.

Assuming, then, our dissociation voltage as constant at 2.35 volts, and further assuming that the current flowing through the solution is constant, then the only variable left which can affect the potential difference across the electrodes is the change in the electrical resistance of the electrolyte. Since this change in electrical resistance is directly due to the increase in acidity caused by the electrolytic action as explained above, it is evident that a knowledge of this change of resistance is of considerable importance. The accompanying curve (Fig. 4) shows the decrease in electrical resistance due to a corresponding increase in acidity, as a zinc sulphate solution containing at the start 100 grams of zinc and 0.0 grams of acid per liter of solution was electrolyzed.

By Ohm's law, the potential difference between two points in an electrical circuit is equal to the electrical resistance between these two points multiplied by the current flowing in the circuit. Therefore assuming a constant current of "A" amperes and resistances of "r" ohms from anode to cathode, the potential difference between the anode and the cathode would be (2.35 + Ar) volts. The dotted curve in Fig. 3 shows the variation of this voltage with increasing acidity. By comparing the theoretical dotted curve with the full line curve based on actual measurements, the similarity in the two is at once evident, although the numerical values for the ordinates are different. This difference in ordinates is due to two facts—first, the solid curve was obtained under actual working conditions while the dotted curve was plotted from data obtained under ideal conditions, and second, the current density in the two was quite different.

Energy Consumed

In buying electrical energy, we pay for the watt-hours consumed, and a watt-hour is the product of the current flowing in amperes times the electromotive force in volts times the time in hours. It is evident, then, that the cost of electrolyzing a zinc sulphate solution is going to vary only with the variation in voltage, since the current and time are constant qualities; and furthermore that this cost will vary with the acidity of the solution, since this is the factor which causes a variation in voltage. Therefore the higher the acidity of the solution to be electrolyzed the cheaper will be the power costs. Unfortunately, however, the higher the acidity the lower is the current efficiency or the actual amount of zinc recovered. We have, then, a case of two conflicting factors; for with zero acidity we should get 100 per cent current efficiency, but our voltage would be high, while with high acidity our voltage would be low but the yield of zinc would be poor. Obviously there is a zone of best working conditions which it would be well to determine. Assuming a constant current flowing through the solution and our theoretical voltage variation as expressed above, and using the values for the variation in resistance as shown by actual measurements in Fig. 4, we can calculate the power in watts or the energy in watt-hours required to produce a pound of zinc under varying conditions in acidity. Furthermore, from the acid-efficiency curve, Fig. 2, we can pick off the values in percentage yield of zinc under similar conditions of acidity, and by combining these figures we can obtain an expression of the kilowatt-hours required to produce a pound of zinc under varying conditions of acidity in electrolyte. The dotted curve in Fig. 5 represents such a calculation, while the solid curve represents the power required to produce a pound of zinc under actual operating conditions with variation of acidity in the electrolyte. The striking similarity between these two curves is a further proof of the theories advanced.

Electrolytic Practice

While all of the foregoing theories must be kept in mind, in practical electrolytic zinc work there are a

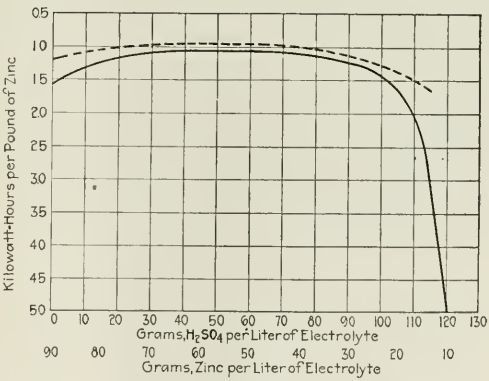


FIG. 5. DOTTED CURVE REPRESENTS THE AVERAGE OF A NUMBER OF POINTS CALCULATED FROM THE DATA OBTAINED AS EXPLAINED IN THE TEXT. SOLID CURVE REPRESENTS ACTUAL MEASUREMENTS AND WITH ALLOWANCE FOR ERRORS IN MEASUREMENT IS ENTIRELY COMPARABLE WITH THE DOTTED CURVE

great many other factors which still further complicate matters. One of the most important of these factors is the effect of impurities in the electrolyte on the deposit and also on the efficiency of recovery. In the first

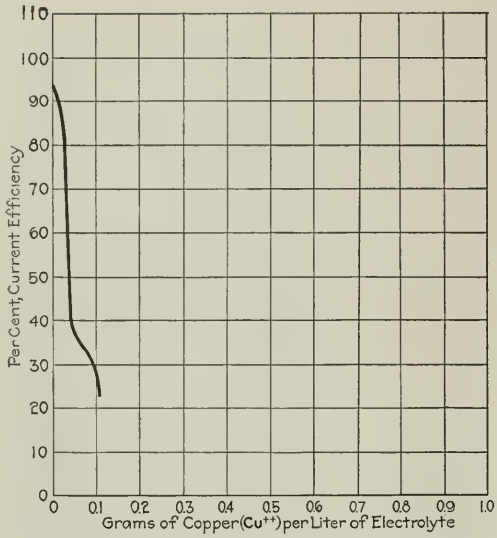


FIG. 6. CURVE SHOWING THE EFFECT OF VARYING AMOUNTS OF COPPER ON THE EFFICIENCY OF RECOVERY

part of this paper dealing with the purification of the electrolyte, the fact was brought out that metals with a lower electro-potential than zinc could be replaced from their solutions by metallic zinc. If this purification process is not carried out to completion, traces of other metals will be found in the electrolyte and, under

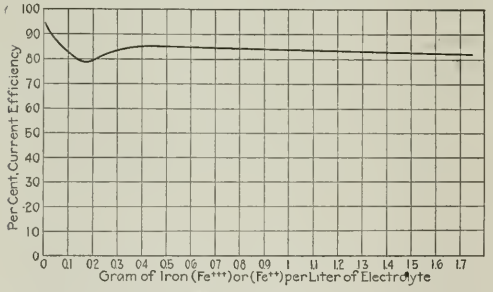


FIG. 7. CURVE SHOWING THE EFFECT OF VARYING AMOUNTS OF IRON IN THE ELECTROLYTE ON THE EFFICIENCY OF RECOVERY

certain conditions, will replace the zinc plated out of solution with astonishing rapidity, eating holes in the deposit and sometimes completely removing a heavy deposit of zinc. The chief offender in this line appears to be copper, as little as 40 milligrams of copper (Cu^{++}) per liter of solution being absolutely fatal to electrolysis. The curves shown in Figs. 6 to 9, inclusive, show the effect on the percentage current efficiency (ratio of actual zinc recovered to theoretical recovery) of varying amounts of the more common contaminating metals. These curves are the results of actual measurements in a solution containing 80 grams of zinc per liter, 2 to 3 per cent acid and varying amounts of the impurities under discussion. The current density in all cases was maintained at 17 amperes per square foot.

The point might be raised that these curves represent only one set of conditions in regard to zinc and acid concentration in the electrolyte. This is quite true; but in the first place, this set of conditions was found to be the best all-round working conditions for the plant and is, therefore, the only set in which we are interested. In the second place, experiments showed these curves to be representative of a family of curves when the zinc and acid concentration were varied. All the curves in each such family were quite similar in contour and varied only by a constant. As would naturally be expected, the efficiencies were always lower when the acidity was increased and the effect of any one impurity was therefore accentuated in a more strongly acid solution.

These curves are true only when the one impurity under discussion is the only impurity present in the electrolyte, and the cumulative effect of a number of

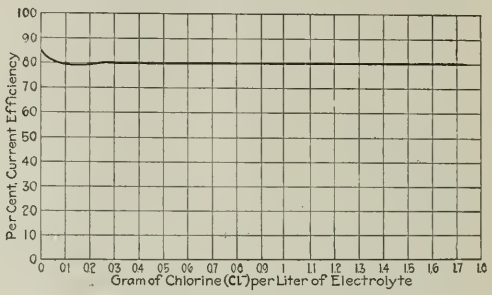


FIG. 8. CURVE SHOWING THE EFFECT OF VARYING AMOUNTS OF CADMIUM ON THE EFFICIENCY OF RECOVERY

these impurities in one solution undergoing electrolysis is naturally greater than any individual case such as we have discussed. This cumulative effect, however, is small through the range of concentration actually met with and the best way in which to determine it is by an actual measurement of the efficiency under the conditions it is desired to investigate.

The curve in Fig. 9 showing the effect of chlorides represents a series of measurements made on a solution containing varying amounts of sodium chloride and is interesting chiefly because it shows that the presence of an anion other than the SO_4 radical does not ma-

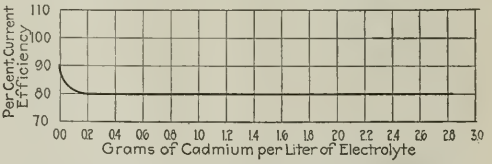


FIG. 9. CURVE SHOWING THE EFFECT OF VARYING AMOUNTS OF NaCl IN THE ELECTROLYTE ON EFFICIENCY OF RECOVERY

terially affect the yield of zinc. The chlorides do, however, attack the insoluble lead anodes to an appreciable extent.

There are some impurities which apparently can build up in the electrolyte to a comparatively high concentration without any bad effects. These impurities are practically all above zinc in the electromotive series

and include such metals as chromium, manganese, aluminium, magnesium and the alkalies.

A great deal has been said and written concerning the presence of an alkali sulphate in the electrolyte, some authors claiming a marked improvement in efficiencies with sodium sulphate present, others claiming that even small amounts are detrimental. In the Nahnsen process for electrolytic refinement of impure zinc anodes, from 100 to 300 grams of sodium sulphate per liter are used. In the author's invesigation of the effect of sodium sulphate in the electrolyte on the efficiency, varying amounts were used, but no variation in current efficiency resulted except when a high percentage of acid was present. It is probable, therefore, that the presence of sodium sulphate in the electrolyte merely contributes an increase of SO_4 ions, thereby causing a corresponding suppression of hydrogen ions and an increase in current efficiency, or yield.

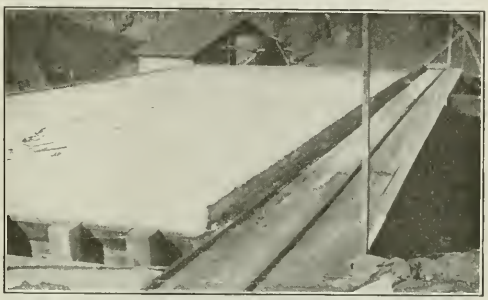
At various times in the history of electrolytic work, not only in zinc but in the electrolytic recovery of all metals, some one operator has discovered and used some simple organic compound in his process which has had decidedly beneficial results. These substances are usually called "additive agents" and probably the most common is ordinary ground glue. The author tried several of these compounds and, while the results were not at all certain, yet there seemed to be less gassing, less heating and a more uniform current distribution when a small amount of glue was kept in the electrolyte circulating system. Excessive amounts were decidedly bad, causing an increase of gassing and a pitting of the surface of the deposited zinc.

At Ducktown the electrolysis was carried out in lead-lined wooden tanks, the lining of each tank being entirely separate from all the others. It was feared at

FILLING THE STORAGE TANK WITH SLUDGE FROM THE ACID PLANT CHAMBERS. THE DUMP CAR AND TANK ARE LEAD LINED

first that this construction might cause trouble due to short circuits and ground leaks, but in practice the lead-lined tanks proved very satisfactory. The partition between each two tanks was broad enough to support the equalizing bus bar and the insulators on which one end of the electrodes rested. There were in all thirty tanks or cells in series with ten cathodes and eleven anodes per cell. The voltage across the entire thirty cells was 115 volts, or 3.83 volts per cell. The loss in contact between the electrodes and bus bars was about 0.4 volts per cell, giving an actual useful voltage of 3.43 volts. The line drop and leakage on the total electrical circuit was about 6 volts. Expressing these figures in percentages, the actual useful voltage was 85 per cent, the contact loss 10 per cent and the line drop loss 5 per cent.

While the cells were connected in series electrically, they were fed individually with solution from a common launder, or we might say the circulating system was a parallel circuit. This circulating system was so arranged as to maintain a constant concentration of zinc and acid in the cells. The way in which this was



STORAGE TANK FULL OF SULPHATE SLUDGE

accomplished was quite simple. A large air lift was installed which was fed from a collecting tank under the floor of the cell room. Across the front of the cells there was built a lead-lined launder; overflow pipes from each cell discharged their solution into this launder; the launders in turn discharged into the collecting tank above referred to. The solution was then pumped by means of the air lift to a distributing tank mounted well above the level of the cells. It was led by means of a lead pipe into a lead-lined distributing launder which in turn fed each individual cell through a small lead pipe. The rate of circulation was about 100 gallons per cell per hour.

From the lower circulating tank a second and much smaller air lift continually withdrew a small amount of solution. The solution thus withdrawn was returned to the leaching tanks, while at the same time an equal amount of strong neutral solution was added to the circulating system by means of the top circulating tank. The quantity of solution added and withdrawn was so controlled as to maintain a constant concentration of zinc and acid in the cells.

The average analysis of the solution in the cells showed 70 grams of zinc per liter and about 3 per cent acid, and under these conditions of electrolyte the current efficiency averaged 60 per cent.

The only unfortunate feature in this process was the rehandling of so much solution; for in order to neutralize the acid by the calcium carbonate method, the solution had to pass through the Oliver filter a number of times, and in each of these passages some zinc was lost, so that the total loss in zinc in the filtration was high, notwithstanding the fact that each individual passage through the filter showed excellent recovery.

The electrodes used were the usual aluminium cathodes and lead anodes. These electrodes were suspended from aluminium bars, to which they were rigidly

bolted. These bars in turn rested on the aluminium equalizing bus on one end and on a porcelain insulator on the other end. At first the pressure between the aluminium bar and the bus was depended on for electrical contact, but this caused no end of trouble. If one contact became slightly corroded between the surfaces while another contact on the same bus remained good, then the electrode with poor contact would cease to carry any current due to the increased contact resistance, while the electrode with good contact would double its current. Under these conditions the electrode with poor contact would cease to be effective and the zinc deposited on it if a cathode, or by it if an anode, would immediately begin to dissolve in the acid electrolyte, while the electrode carrying double its normal current would become dangerously hot and give off considerable gas. In order to get away from this trouble and insure certain contacts, the aluminium bars from which the electrodes hung were eventually securely bolted to the equalizing bus. A further prevention was the coating of the surfaces of the contacts with vaseline to insure

ONE SIDE OF THE CELL ROOM, SHOWING THE FEED AND OVERFLOW SYSTEMS AND THE METHOD OF HANGING THE ELECTRODES. THERE ARE SHOWN ONLY 3 ANODES AND 2 CATHODES PER CELL

against corrosion. In this way very satisfactory operations were obtained.

Above the surface of the solution during electrolysis there is a great deal of gas and mist, the mist apparently being very fine drops of the electrolyte carried into the air by the gas bubbles rising from the electrodes and bursting at the surface. This mist was very irritating to the mucus membranes of the men working on the cells, and in order to eliminate it the tops of the cells were closed in by a sort of hood which could be raised at will out of the way of the operator. A ventilating fan, connected up with these hoods by means of a system of flues, drew all this mist out of the building and discharged it harmlessly out of doors.

The thirty cells in series were divided into three groups of ten, and a fourth group of ten cells was held as a reserve. The current was led to and from each of these sections through large single-pole switches. These switches were so arranged that any three of the four groups of cells could be connected in series at one time. Furthermore, the fourth group could be cut in and any other group cut out without shutting down the generator. By this means an absolutely continuous operation was maintained, the groups of cells rotating in order and each group being plated 72 hours. By this method one group of ten cells was cut out each day of twenty-four hours and another group cut in, thus giving a full day to the stripping and cleaning of the cathodes from each group of cells.

The deposit of zinc on the cathodes was usually fairly smooth, a few nodules appearing on the surface and occasionally some treeing, but on the whole a smooth deposit of uniform thickness was obtained. A great deal of trouble was encountered at first with a blistering or bulging of the deposit of zinc. The metal did not appear to cling tightly to the aluminium cathode. This trouble was never completely cured but was relieved very materially by a careful and painstaking cleaning of the aluminium cathodes each time they were stripped.

The zinc recovered was on the whole of very superior quality, the chief impurity being cadmium. The average of a great number of analyses gave 99.90 per cent zinc, with about 0.05 per cent cadmium, 0.03 per cent lead and the rest iron and copper.

The power required to produce a pound of zinc varied from 2.5 to 2.8 kw.-hr.

The sheet of zinc stripped from each side of the cathode will weigh about ten pounds. The stripping of these sheets is a very simple operation; one man can strip both sides of as many as 240 cathodes in ten hours.

In order to market this zinc it must be put in the form of 50-lb. slabs. This means melting all the electrolytic zinc stripped, but as the melting process is a very simple one and almost any type of furnace can be adapted to this purpose, this problem was never a serious one. The zinc in melting down has a tendency to form a spongy mass. Furthermore, while the melting point is about 420 deg. C., the metal must actually be melted at a temperature around 700 deg. C., in order that it may be poured successfully. And at this temperature care must be exercised or the loss by oxidation will be high. It has been found that the addition of a small amount of ammonium chloride to the molten bath has a tendency to break up the sponge zinc and also to minimize the loss by oxidation. The total loss in melting should never exceed 4 per cent of the metal melted, while with large pots or a reverberatory hearth this loss should be materially decreased.

The Aluminium Bronze Industry

By W. M. Corse

METALLIC aluminium has been known for a long time, and its use in copper alloys was discovered about 1855 by Lord Percy. The high cost of production of metallic aluminium retarded its commercial development, and it was not until the discovery of the electrochemical processes for its production that it came to be known as a common metal.

I have been particularly interested, for the past few years, in working with the alloy known as aluminium bronze, which is usually composed of approximately 90 parts of copper and 10 parts of aluminium, by weight. This alloy has many properties similar to the copper-tin bronzes, and it has been of interest to find just where the copper-aluminium bronzes could be sub-

*Read before the Institute of Metals, A. I. M. E., at Milwaukee, Oct. 9, 1918.

stituted for the copper-tin bronzes, and in that way conserve the use of metallic tin.

Copper-aluminium bronzes have practically double the tensile strength of tin bronzes, so that a smaller cross-section frequently can be adapted, with the same mechanical result. Their resistance to shock is superior to that of the copper-tin bronzes, and their resistance to wear is in some cases superior and in some cases practically equal. Consequently, for many mechanical uses, where a hard bronze is desired to replace one containing 10 to 11 per cent of tin, for example, an aluminium bronze of about the composition mentioned will be found worth investigation. Undoubtedly no two alloys possess exactly the same properties, and when a substitution of one for the other is desirable it is necessary to work out special methods of handling the substitute in order to get practically the same results.

As is frequently the case in such work, special properties are found to be superior to those of the metal originally used and other properties are discovered to be not so good. As a particular instance of the substitution of aluminium bronze for phosphor bronze, I would cite its use in worm gearing. The following table and curves taken from my paper[1] on this subject before the Society of Automotive Engineers will give an idea of the different properties:

TABLE I

PHYSICAL PROPERTIES OF PHOSPHOR BRONZE

Composed of 88.7 parts of copper, 11 parts of tin and 0.3 parts of phosphorus

Ultimate tensile strength, lb. per sq.in.	35,000-40,000
Yield point, lb. per sq.in.	22,000-25,000
Elongation in 2 in., per cent	6-10
Reduction of area, per cent	7-9
Specific gravity at 20 deg.	8.8
Brinell hardness number (500 kg. load for 30 sec.)	75-85
Pattern maker's allowance for shrinkage, in. per ft.	0.125
Weight per cu.in., lb.	0.31
Compression, elastic limit, lb. per sq.in.	16,000
Coefficient of friction	0.0040
Modulus of elasticity	12,000,000 to 14,000,000
Resistance to impact, Fremont notched-bar test (fractured section 7 x 10 mm.), kg.meters	2 to 4
Endurance of alternation impact, Landgraf-Turner or Arnold test, alternations	150 to 400
Resistance to shear by impact, McAdam machine, ft.-lb.	300 to 450

Aluminium bronze containing 10 per cent of aluminium and 1 per cent of iron has the physical properties shown in Table II.

TABLE II

PHYSICAL PROPERTIES OF ALUMINIUM BRONZE

Containing 10 per cent of aluminium and 1 per cent of iron

Ultimate tensile strength, lb. per sq.in.	65,000-80,000
Yield point, lb. per sq.in.	23,000-28,000
Elongation in 2 in., per cent	20-30
Reduction of area, per cent	21-29
Specific gravity at 20 deg.	7.5
Brinell hardness number (500 kg. load for 30 sec.)	92-100
Pattern maker's allowance for shrinkage, in. per ft.	0.22
Weight per cu.in.	0.27
Compression, elastic limit, lb. per sq.in.	19,000
Coefficient of friction	0.0025
Modulus of elasticity	15,000,000-18,000,000
Resistance to impact, Fremont notched-bar test (fractured section 7 x 10 mm.), kg.-meters	7 to 10
Endurance of alternating impact, Landgraf-Turner or Arnold test, alternations	3500 to 5500
Resistance to shear by impact, McAdam machine, ft.-lb.	750 to 850

It is of interest to note that aluminium bronze would undoubtedly have been substituted for phosphor bronze before this had the manufacturing difficulties with the former been surmounted. Aluminium bronze, when cast in the foundry, presents about as difficult a problem as I have ever seen. It is very sensitive to gas absorption and must be handled extremely carefully to insure good castings. It is similar, from a foundryman's standpoint, to manganese bronze, in that it requires large risers and careful pouring to insure clean castings. Several years' work on this alloy has demonstrated conclusively that it is perfectly possible to make as large a percentage of good castings from it as from any other non-ferrous alloy. It seems to me therefore that its use should be increased, particularly in view of the shortage of tin at the present time, and undoubtedly new fields will be opened up as its various properties are better known.

One feature that stands out prominently, which was mentioned by the eminent English investigators of this type of alloys and published by them in the 8th and 9th reports of the Alloys Research Committee of the Institution of Mechanical Engineers of Great Britain, is the fact that cast aluminium bronze possesses properties equal to those of rolled aluminium bronze. Nearly all copper-base alloys are improved by rolling processes, but the copper-aluminium alloys seem to possess equally good properties when cast or rolled; this is a remarkable metallurgical fact. Another important property of these copper-aluminium alloys is their resistance to alternating stress. Many tests indicate that their resistance is greater in this respect than that of some steels, and I have seen instances when cast aluminium-bronze bolts have outlived five steel bolts in foundation work subject to severe shocks. I mention these various instances to indicate that work originally started as research for substitution of one material for another frequently develops an article which has properties not possessed by the original metal or alloy.

I have dwelt particularly on the aluminium bronzes because recently I have done more special work on them than on other alloys, but I believe that the use of aluminium itself in many combinations of metals is a very important subject for investigation. Undoubtedly after the war the cost of aluminium will be reduced from its present price, and considering its low specific gravity it offers a very interesting and important field for research in the non-ferrous business. Naturally, if combinations containing aluminium can be developed, in view of a probable increasing supply of metal the cost will be reduced. This will benefit the industry generally and will immediately conserve tin.

Niagara Falls, N. Y.

[1] *Journal* Society of Automotive Engineers, April, 1918.

Future of the Barium Industry*

BY WILLIAM H. ROLLIN

THE future of the barium industry, to my mind, is almost entirely dependent upon whether the Government raises a protecting tariff or not, and it seems to me most appropriate that we should proceed without very much delay so as to get our houses in order against the time when this country will have tremendous competition in those materials which we have made since the beginning of the great war. There are several contributing causes which lead me to think this.

The barium industry in this country is in its infancy and has not had time to become well established or financially strong. The makers of machinery suitable to this industry are lacking in experience and many of their products appear quite crude in comparison with some of the European machinery, and then, for some strange unknown reason, barium products have

*Read at the Chicago meeting of the American Institute of Chemical Engineers, Jan. 15, 1919.

always been manufactured on a very small margin of profit and this, in conjunction with the fact that wages in the United States are at least 100 per cent higher than in other countries, would indicate to me that, without the above-mentioned tariff wall to shelter behind, the barium industry will cease to exist in this country in the very near future.

The question of freight rates will also play an important part in determining the future importance of this industry, for we must remember that the consumer can afford to buy our goods only if they are as good in quality and as cheap as the foreign goods.

Now the tendency seems to be for our railroad freights to keep rising and I see very little hope of their being reduced, especially under Government supervision, which, as we all know, is uneconomical and more expensive than private management. On the other hand, the end of the world war leaves the shipping of the world in better shape than it ever was.

Ocean Freight War Foreseen

For the first time in many years the American mercantile marine will enter into the race as a serious competitor against Great Britain, France and Holland. I foresee in the near future an ocean freight war, which will make transportation by water extremely cheap, and if this takes place it will, of course, do its part toward annihilating the barium industry in the country, provided the industry is not given proper protection.

We have information from Europe that the various Governments there are encouraging the consolidation and amalgamation of various interests engaged in the chemical industry, purely with the idea of strengthening their position and their financial condition and putting them in a position to effect great economies in overhead expenses, all with a view toward invading the world's markets with their products and preventing, if possible, the balance of power in the chemical industry from swinging to America.

It is quite obvious that an industry of this kind, which now employs a small army of men, should be maintained and preserved in such fashion that the industry can live, and I would suggest not only tariff protection, but laws which will permit the responsible manufacturers in the same line to meet and discuss freely the costs and selling prices. On the other hand, we, in the United States, are up against the Sherman anti-trust law and numerous other laws of like character, which forbid and make criminal any effort at consolidation or co-ordination of interest and prevent any steps being taken to form the various units of the several branches of the chemical industry into any kind of a league for their self-protection and preservation.

I should, therefore, recommend as a relief and as a protection, that immediate attention be given to our needs by the legislators, and while I do not ask for an excessive tariff at once, I feel that for economic reasons we must have protection, not against Germany alone, but against those other countries which are now ready to compete under a lower wage scale and with cheaper freights.

The system of taxation to which the Government has resorted to meet the expenses incident to the great war, while no doubt very efficient as a medium of obtaining money, is, in my opinion, ill-advised in some respects, in so far as it seems to bear down with undue weight upon manufacturers in general. This pressure is felt most acutely by such new industries as our own. We find a difference between our Government and the Governments of European countries, who in an endeavor to help and stimulate their growth, in the case of many young industries, declared them to be tax-free until the time that they are financially capable of bearing their proportionate share of the country's expense.

As far as the volume of business is concerned, the barium industry is active or inactive in direct proportion to the business activity or inactivity of the country as a whole.

Barium products, including barium peroxide, barium chloride, barium nitrate, barium carbonate, barium sulphide, etc., depend for their sale on so many diversified interests that the volume of business which can be done in them is a very good index as to the general condition of business throughout the country, and the stoppage or the elimination of the barium industry would have a very deleterious effect on a great many other industries. For instance:

Barium Products Used in Many Industries

Barium peroxide is used in the times of peace for the manufacture of U.S.P. hydrogen peroxide and as a bleach, especially in the straw hat and blanket industries.

Barium sulphate (precipitated), known in the trade as blanc fixe, is used in the manufacture of automobile tires, in the paper industry, in making printer's ink, in pigments and in many other ways.

Barium sulphide, also known as black ash, is used with zinc sulphate to manufacture lithopone.

Barium carbonate has widely diversified uses in the manufacture of scumless brick, in rat poison and high grade optical glass, etc.

Barium chloride is largely used in the dye industry, is absolutely necessary in the manufacture of photographic materials and enters into the manufacture of a great many other chemical compounds.

Barium hydrate finds its largest use in the beet sugar industry.

Barium nitrate enters into the manufacture of fireworks, detonators, railroad signals and, of course, enters very largely into munition making, as well as having numerous other peace-time uses.

Sodium sulphide, while it can scarcely be talked of strictly as a barium product, is, nevertheless, available as a by-product of the manufacture of certain barium products. It is absolutely essential to the making of sulphur dyes and is the most extensively used depilatory in the conversion of hides into leather.

I have only mentioned a very few of the uses of barium products, but enough, I hope, to allow you to readily see of what importance these uses are and to give you an idea of the necessity of making conditions such that the barium industry will not perish.

To sum up: To put the barium industry on a sound commercial basis in this country we require, first, a strong tariff wall; second, reduced freight rates; third, the right to organize, and fourth, a little more consideration from the Government in the matter of taxes. Given these four items, I would say that the barium industry in the United States has a great future.

The Manufacture of Hydrocyanic Acid

Compressed Hydrocyanic Acid to Be a Commercial Commodity—Generation of the Gas for Industrial Purposes, Description of Semi-Industrial Apparatus and Plans for a Large-Scale Operation—Yields and Production Capacity

By H. A. PELTON and M. W. SCHWARZ*

HYDROCYANIC acid was produced for use in the manufacture of cyanogen chloride and for other experimental work. The problem of hydrocyanic acid manufacture may be of interest commercially in connection with the fumigation of fruit trees. At the present time most of the hydrogen cyanide employed for this purpose is prepared on the grounds from cyanide and sulphuric acid, inclosing the trees to be treated in a tent. By employing liquid hydrocyanic acid in cylinders, the trees can be treated with an attendant saving in materials, apparatus and labor accompanied by a more efficient fumigation. It is also possible that hydrogen cyanide may replace carbon monoxide and other gases in fumigating vessels.

Method Employed

The method employed, in brief, consists in adding sodium cyanide solution to dilute sulphuric acid; the water vapor in the evolved gases is removed by fractional condensation, and the concentrated hydrogen cyanide is then condensed at atmospheric pressure. To expel hydrogen cyanide dissolved in the reaction mixture, the latter must finally be brought to the boiling point. Hydrocyanic acid forms dark tars with excess of sodium cyanide, and the cyanide is therefore added to the acid and an excess of the latter over the theoretical amount is employed. The residual liquor in the apparatus after the completion of the reaction must be promptly discharged, as on cooling sodium sulphate crystallizes out. The apparatus (illustrated in Fig. 1) consisted of a 50-gal. steam-jacketed kettle, lead-lined and provided with a lead-covered agitator. The kettle was fitted with a thermometer well, inlet for cyanide solution, and bottom discharge closed by a lead-lined valve. Vapor leaves the kettle through a column, consisting of a 6-ft. length of 4-in. iron pipe, packed with large lumps of coke; the latter is supported by a perforated lead plate, placed at the bottom of the column and between the flanges so that it forms a gas-tight metallic gasket.

Apparatus Explained

The reflux condenser is mounted above the column, and consists of about 30 ft. of 1-in. iron pipe, mounted in a half barrel and cooled by ice. Vapor from the column enters the top coil of the reflux; the lower coil leads into a separator, consisting of a tee. Vapor and condensate enter at the top of the tee through a long nipple; vapor leaves through the side opening, and condensate drains from the bottom, and back to the top of the column, through a trap.

The vapor outlet from the separator is piped to the main condenser; the latter is composed of 9 turns of 1-in. iron pipe, 3 feet in diameter. The coil is mounted in a wooden tub, and cooled by cracked ice.

Condensate from the main condenser is received in a sheet-iron cylinder, 12 in. diam. x 24 in. The receiver is mounted in a barrel and provided with a bottom outlet and vent; the latter consists of a vertical length of ½-in. pipe, the upper end bearing an inverted U. A sight glass is inserted in the line between the

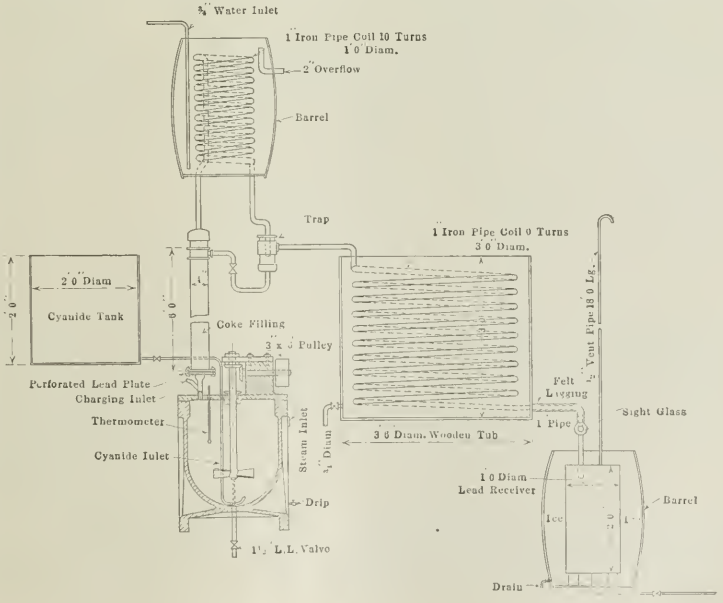


FIG. 1. APPARATUS FOR MANUFACTURE OF HYDROCYANIC ACID

*Published by permission of the Director, Chemical Warfare Service, U. S. A.

condenser and receiver. Product is charged in steel cylinder, with valves removed.

The sodium cyanide container is a sheet-iron cylindrical vessel, with bottom outlet piped to the reaction kettle.

Method of Manufacture

The kettle is charged with 54 lb. of water and 54 lb. of 66 deg. B. sulphuric acid added, bringing the temperature of the mixture to about 70 deg. C. Forty pounds of sodium cyanide (96 to 98 per cent) are dissolved in 100 lb. of warm water in the sheet-iron container, which is then covered.

The condenser, reflux and receiver are packed in ice, the agitator started and the cyanide solution run into the kettle. The addition should take from 1½ to 1¾ hours. Steam is then turned into the jacket of the kettle, and the mixture brought to the boiling point.

The approximate cost of production is calculated below:

	Cents per lb. of HCN.
Sodium cyanide at 31.5c.	74.2
Sulphuric acid at 2c.	6.4
Steam, power, ice, etc.	10.0
Labor	14.3
Overhead and repairs	2.5
	107.4

The charges for power, labor, overhead, etc., can be materially reduced if units of larger capacity are employed.

Proposed Improved Plant

Fig. 2 is a drawing of a proposed plant in which various improvements are embodied. Provision has been made for brine cooling and for more accurate temperature control.

As the stability varies with the purity of the product, a bisulphate tower has been introduced for the purpose

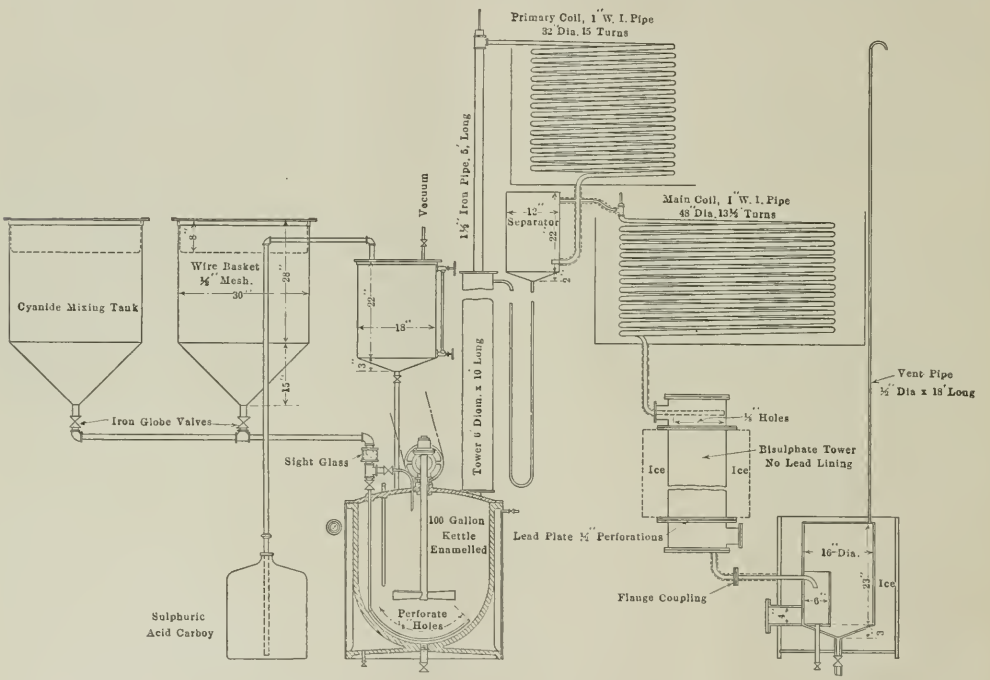


FIG. 2. A PROPOSED HCN APPARATUS

The residue is discharged while warm, and the kettle and discharge lines flushed out.

When the receiver contains a sufficient amount of product, it is drained into an open steel cylinder, previously weighed and cooled. The valve is then inserted, after applying red lead to the thread.

Yields and Production Capacity

An average yield of 78 per cent of the theoretical yield of hydrocyanic acid has been obtained. When the apparatus is properly manipulated the product runs from 90 to 95 per cent HCN. A production of 250 lb. per 24 hours has been obtained by the method herein described, and a total of 7000 lb. manufactured.

of obtaining a more anhydrous product. The receiver is designed to separate any solids carried over from the tower.

In conclusion, the writers wish to express their appreciation of the many helpful suggestions offered by Dr. James R. Withrow, and also wish to thank George O. Kildow for his assistance in the work.

This work was started under the Bureau of Mines of the United States Department of the Interior, and was continued under the Research Division, Chemical Warfare Service.

Small Scale Production Section,
Research Division, C. W. S.
American University Experiment Station,
Washington, D. C.

Influence of Temperature Upon the Action of Slag Upon Refractory Materials

By Raymond M. Howe*
Industrial Fellow, Mellon Institute, Pittsburgh, Penn.

DURING the present period of intense industrial activity, the linings of the various furnaces have played a very important rôle in determining their capacities. In some cases the firebrick or special shapes have given long continuous service, while in other cases the results have not been as satisfactory. As a result, there has been some contention between the consumers and manufacturers of firebrick as to the relative merits of this product, the consumers often claiming that it is not of the pre-war standard and the manufacturers maintaining that it is of equal quality. The latter maintain that the shorter life of refractories, when encountered, is often due to the more severe duty which is imposed upon their product during the struggle for an ever-increasing output of metals.

The work here presented was carried out for the purpose of determining the action of various slags at different temperatures on several standard brands of firebrick. The data secured would therefore appear to bear directly upon the question at issue, for it is well-known that a common means of increasing production consists of increasing the working temperature.

The general plan was to secure bricks of recognized quality and to test the action of several slags upon them at different temperatures. The method used for determining this action was essentially the same as is used at the Carnegie Steel Co.

Work done at that laboratory has shown that if a brick is heated to a definite temperature and thirty-five grams of slag are placed in a cavity at that temperature and are allowed to act for two hours, valuable information can be secured.

Before adopting their method certain points were checked pertaining chiefly to the influence of the time of action of, and the quantity of slag used, upon the

TABLE I—INFLUENCE OF TIME AND QUANTITY OF SLAG USED UPON RESULTS SECURED FROM SLAG TESTS

Penetration of 35 grams of slag in two hours	0.64
Penetration of 35 grams of slag in four hours	0.68
Penetration of 35 grams of slag in six hours	0.64
Penetration of 105 grams of slag in two hours	0.76
Penetration of 105 grams of slag in four hours	0.72

results secured. Tests were made in which the time and slag were trebled, but this procedure failed to produce a more pronounced action.

In reporting the results the total cross-section of the slag saturated area was first measured by means of a planimeter. The area of the original cavity was then subtracted from this. The difference represented the area of the section which had been penetrated by the slag. This area when divided by the linear surface of contact gave a value which represented the square inches of penetration per inch of contact.

The results given in Table I confirm those reported by Nesbitt and Bell and lead to the same conclusions, i.e., when a brick having a cavity 2½ inches in diameter is treated with 35 grams of slag and it is allowed to react for two hours satisfactory results are obtained. In the preceding work 35 grams of slag reacting for two hours resulted in a penetration value of 0.64. When the severity of this test was increased 600 per cent, the penetration factor increased but 12.5 per cent.

Method of Procedure

In view of this preliminary work, the following definite method of procedure was adopted:

The test bricks, each having two cavities 2½ inches in diameter by ½ inch in depth, were heated slowly to the temperature at which the test was to be made. This temperature was held for 1½ hours. Thirty-five grams of slag were then introduced and were allowed to react at this temperature for 2 hours. The bricks were then allowed to cool, were cut through the center of the cavities, and the penetration was noted in the manner previously described.

TABLE II

Slag	Blast Furnace	Heating Furnace	Basic Open Hearth	Acid Open Hearth	Zinc	Copper
Silica	37.32	34.16	18.42	46.48	34.30	28.20
Alumina	13.21	6.13	3.85	5.45	14.74	2.20
Iron	1.62	43.60	14.55	29.30	21.00	2.10
Lime	42.20	1.30	44.10	2.16	2.33	2.51
Magnesia	2.35	0.65	6.32	0.00	7.07	2.14
Manganese	1.11	0.55	5.09	9.08	6.77	0.00
Sulphur	1.20	0.27	0.42	0.38	5.88	0.14
Phosphorus	0.00	0.02	0.58	0.00	0.02	0.24
Copper	0.00	0.00	0.00	0.00	1.28	58.21
Zinc	0.00	0.00	0.00	0.00	8.20	0.00
Melting point	1220°C.	1050°C.	1275°C.	1400°C.	1025°C.	1020°C.

Six slags, which were secured from the Carnegie Steel Company's laboratory, were used during the tests. Their analyses and fusion points are given in Table II. The three bricks used are designated by *A*, *B* and *C*.

Experimental Data

By following the method already described and varying the brick, the slag and the temperature, one at a time, average results were secured as shown in Tables III to VIII.

In each case the slag penetrated more deeply into the brick at higher temperatures. In several cases an increase of 100 deg. C., or less than 10 per cent, resulted in nearly doubling the penetration.

This increased penetration has several effects in actual practice. One effect concerns the strength of the brick itself. It is a known fact that bricks when saturated with slag are not so strong at high temperatures as when they are free from slag. This decreases their ability to sustain the weight of the other parts of the furnace.

The refractories of the lining is also decreased when it becomes soaked with slag.

The lining is also subjected to more severe chemical action. This action takes place rather slowly in many cases, but rapidly in others. In any event, the action takes place sooner when the slag forces its way further into the inner portions of the lining. Being more active at higher temperatures, its solvent power is also increased.

In view of these tests, it appears very much as if the relation of output and the life of the lining is similar to the rate of driving and the life of an automobile. Cars which operate successfully for 50,000 miles when driven at the rate of twenty miles per hour give much less service when driven forty miles per

*Paper read before a meeting of the Refractories Manufacturers Association on Nov. 20, 1918.

hour. These same cars when subjected to the gruelling ordeal of a stock car race often fail to complete the first hundred miles.

Lives of Furnace Linings Must Be Compared According to a Sliding Scale

Such conditions are constantly encountered when any product is driven to its limit. Such being the case, it is not fair to compare the lives of furnace linings on the daily basis. Neither is it fair to compare them on the tonnage basis, when one furnace is worked at moderate and another at maximum capacity. Under conditions occurring with increased output, they must be compared according to a sliding scale. If a furnace is operated under such conditions that the daily output of metal is increased 50 per cent, it cannot be expected to last as long, or even two-thirds as long (during which time equal tonnage would have been secured), but from one-third to one-half as long. The consumer must realize this and balance his costs under normal production against those under increased production. If the balance is in favor of conditions of increased production, he must, if he uses the most suitable material, expect to encounter continued shorter service from linings.

TABLE III—EFFECT OF VARIOUS TEMPERATURES UPON THE PENETRATING POWER OF HEATING FURNACE SLAG
(M. P. 1050°C.)

Brick	Temperature of Test 1150°C.	1250°C.	1350°C	1450°C.
Type A	0.04	0 09	0. 15	0 34
Type B	0 02	0 05	0.11	0. 79
Type C	0.07	0.10	0.24	0.78

TABLE IV—EFFECT OF VARIOUS TEMPERATURES UPON THE PENETRATING POWER OF BLAST FURNACE SLAG
(M.P. 1220°C.)

Brick	Temperature of Test 1250°C.	1350°C.	1450°C.
Type A	0. 03	0.08	0. 14
Type B	0. 00	0. 11	0. 17
Type C	0.07	0.12	0. 17

TABLE V—EFFECT OF VARIOUS TEMPERATURES UPON THE PENETRATING POWER OF ZINC SLAG
(M.P. 1025°C.)

Brick	Temperature of Test 1150°C.	1250°C.	1350°C.	1450°C.
Type A	0. 03	0. 13	0. 28	0 19
Type B	0. 04	0. 16	0. 29	0. 32
Type C	0. 05	0. 24	0. 33	0. 43

TABLE VI—EFFECT OF VARIOUS TEMPERATURES UPON THE PENETRATING POWER OF BASIC OPEN HEARTH SLAG
(M.P. 1275°C.)

Brick	Temperature of Test 1350°C.	1450°C.
Type A	0. 58	0. 73
Type B	0. 29	0. 33
Type C	0. 44	0. 55

TABLE VII—PENETRATION OF ACID OPEN HEARTH SLAG
(M.P. 1400°C.) AT 1450°C.

Brick	Penetration
Type A	0. 24
Type B	0. 33
Type C	0. 57

TABLE VIII—PENETRATION OF COPPER SLAG (M.P. 1020°C.) AT TWO TEMPERATURES

Brick	Temperature of Test 1150°C.	1250°C.
Type A	0. 46	0. 65
Type B	0. 36	0 57
Type C	0 52	0. 62

Nitric Acid.—The records of the War Industries Board show that the production of nitric acid in 1918 was 634,817 tons of 100 per cent nitric acid. The Chemical Division states that no statistics regarding the production in 1916 and 1917 have been gathered.

Mesothorium Work of the Bureau of Mines

THE demand for radium for medical work, but more particularly for luminous paint, has made the question of possible radium substitutes of considerable importance. Radium luminous paint was used in the war for a number of purposes, more particularly on the dials of instruments used on airplanes, so that these instruments could be read at night; for electric push buttons, door numbers and small images for shrines, etc. The paint is permanently luminous in the dark and contains from 0.1 to 0.25 milligrams radium element to one gram of zinc sulphide. A luminous watch face usually has from ten cents to twenty cents of radium on it.

An excellent substitute for radium for certain purposes is mesothorium. This is a radio-active element found in monazite sand and other thorium minerals. When first extracted it is not in satisfactory condition for luminous paint, but must be allowed to "ripen" for several months or even a year before it can be used. During this time the alpha radiation which is required for luminous paint becomes sufficiently strong. On the other hand the beta and gamma radiation of mesothorium grows rapidly and it can be used for medical purposes within a few days after preparation.

Radium has a long life, half of it decaying in approximately 1600 years. Mesothorium on the other hand has a short life, five or six years being its useful life for luminous paint purposes. The price in the past has varied from 40 to 60 per cent of that of radium, the comparison being on products of equal activity. For medical purposes therefore it cannot compete with radium as long as there is plenty of the latter; for luminous paint, to be used on objects which themselves have a short life, it is an excellent substitute for radium.

Shortly after the United States entered the war the Bureau of Mines made a co-operative agreement with the Welsbach Co. of Gloucester, N. J., for the study of methods of extraction and recovery of mesothorium. The work was carried on at the Rocky Mountain station of the Bureau of Mines at Golden, Colo., under the direction of Dr. R. B. Moore, superintendent of the station, Dr. Herman Schlundt being assigned to the detailed work on the problem. Successful methods of extraction and recovery have been worked out and connected up with the regular metallurgical processes of the Welsbach Co.

The next largest producers of thorium salts in the country about the same time became interested in the recovery of mesothorium and worked out its own methods. Consequently at the present time mesothorium is recovered from practically all the monazite sand treated in the United States.

The details of the work of the Bureau of Mines will be published later. A preliminary announcement was made by Dr. Moore in a paper given at the September meeting of the American Institute of Mining Engineers at Colorado Springs. Incorrrect press reports of this announcement gave rise to some serious misstatements of facts, hence this statement.

The Bureau of Mines has never claimed the discovery of mesothorium, as this element was first identified and described by Hahn in 1905.

Flotation of Oxidized Ores of Lead

Process of Sulphidizing Ores Such as Cerussite, Wulfenite and Cerargyrite — Sulphidizing Agents — Pyrolusite and Other Interfering Elements — Flotation Oils and Results — Consumption of Sodium Sulphide

By GLENN L. ALLEN

IN THE dressing of lead ores a greater recovery of the oxidized minerals is becoming more and more urgent. Concentration of the coarser particles of oxidized minerals of lead usually offers no difficulties not readily met by the time-honored gravity methods, but the recovery of the slime values is often a more difficult problem. Due to its friable nature, the principal oxidized lead mineral, the carbonate, readily finds its way into the slime during crushing and the usual subsequent treatment with jigs and tables. The milling of this carbonate or the mixed carbonate and sulphide ore is therefore almost invariably attended with a serious loss of lead and often of silver in the slime.

In view of the fact that the concentration of the simple sulphide minerals of lead is meeting with success in many flotation mills, it is only natural that the metallurgist should strive to adapt the process to the recovery of slimed oxidized minerals. Gratifying results have been obtained by the use of the ordinary froth-flotation in connection with the sulphidizing process. This is a simple process entailing the use of a small quantity of a commercial chemical, sodium sulphide, or its equivalent.

The Sulphidizing Process

Since the sulphidizing idea is new to many, a brief description of the process, its use, agents and methods may be of value. The process, as applied to lead ores, was tested on a laboratory scale by the Salt Lake City station of the United States Bureau of Mines,[1] to which belongs much credit for directing attention to the possibilities of the process. The writer has since developed and perfected the idea for use on the oxidized lead of the Shattuck-Arizona Copper Co. at Bisbee, Ariz., and the milling data hereinafter given are results of this work.

Sulphidizing is the process of altering oxidized minerals to the sulphide form, at least superficially, to produce a product recoverable by flotation. It consists simply in subjecting the carbonates to be floated to the action of a soluble sulphide such as sodium sulphide. The sulphur molecule of the reagent exhibits a rather remarkable avidity for the lead in the cerussite, and, if the mineral is clean, almost instantly forms a superficial film of lead sulphide on the carbonate particle. This black film is very firm and even exhibits a sub-metallic luster when viewed under the microscope or on the vanning plaque. The amount of sulphidization may vary from a thin film to a complete conversion of the particle. The desired degree of conversion depends on the ore itself and is best determined by actually sulphidizing the ore and then testing it for flotation. In practice, the amount of reagent supplied to an ore is not necessarily a measure of the degree of sulphidization, because elements other than lead in the ore may destroy the usefulness of the sodium sulphide.

With alkaline sulphides, such as of sodium, another factor limits the amount allowable in practice in the flotation pulp, that factor being the alkalinity due to hydrolysis of the sulphidizing agent. Excess alkalinity produces a very bad physical effect on the flotation, but so far as noticed is not detrimental to sulphidization of lead carbonate ores. In the case of sodium sulphide, hydrolysis is said to be nearly complete:

$$Na_2S + H_2O = NaOH + NaHS.$$

Thus for every pound of Na_2S dissolved in the flotation pulp, theoretically about half a pound of NaOH is introduced. Using increasing amounts of Na_2S, it is evident that a point would soon be reached at which the alkalinity would be detrimental to flotation. This is borne out in practice, and the point at which flotation begins to fail is so marked as to be easily detected by the operator. This maximum allowable alkalinity varies with the pulp conditions, especially with the kind and quality of oil used. For example, when treating 5 per cent lead ore in a pulp containing 30.2 per cent solid and using 1.15 lb. of oil per ton of dry feed, the upper and lower limits of sodium sulphide consumption were found to be respectively 3.5 and 1.3 lb. per ton of dry ore. Below 1.3 lb. the froth was lean in lead—probably due to insufficient sulphidization of the carbonate—while on passing 3.5 lb. the froth flattened, dropped its mineral and broke to water, due to the excess alkali. The mixture of oil used consisted of Cleveland Cliffs wood creosote 25 per cent, crude coal-creosote 64 per cent and Pensacola tar and turpentine No. 350, 11 per cent.

Returning to the hydrolysis equation, it would incidentally appear that the $HS^=$ radial is the active sulphidizing agent in this case. In the flotation of cerussite, the chemical action of NaOH may even be beneficial, due to the solubility of lead carbonate in NaOH solution. The exact chemistry of sulphidizing yet remains to be stated. In keeping with the empiricism of flotation the important fact nevertheless remains that the carbonate, once sulphidized, floats almost if not quite as readily as the natural sulphide.

Sulphidizing Agents

Possible agents for use as sulphidizers are elemental sulphur, sulphuretted oils, hydrogen sulphide, various sulphur compounds of sodium and calcium (such as CaS, $Ca(SH)_2$, CaS_6, Na_2S, NaHS, Na_2S_5, Na_2S_x), and

[1] "Flotation of Oxidized Ores." Ralston and Allen. Circular of the U. S. Bureau of Mines, May, 1916.

similar soluble sulphides of other elements. From the practical and commercial standpoint H_2S and Na_2S appear most important at the present time. Both of these are efficient sulphidizers; they are cheap, commercially obtainable, reasonably safe, and not mechanically difficult to handle. Making a comparison, H_2S is probably cheaper and easier to prepare at the mill, is a narcotic poison and is a more active sulphidizing agent, a property not as desirable as at first might be supposed, especially in treating lead ores. Due to its greater chemical activity, however, it is thought to be better for silver. Sodium sulphide, on the other hand, is obtainable normally in car lots at about 2c. per lb. at the factory for 60 per cent Na_2S, is convenient and safe to use, has less available sulphur per unit and when used in excess produces undesirable conditions in the flotation pulp. Being less active chemically than H_2S, it does not so readily attack and sulphidize iron compounds, especially limonite, which so often occurs with lead carbonate. Thus the use of Na_2S often tends toward cleaner concentrates both in iron and insoluble contents. Sodium sulphide is a depilatant, softens the finger nails and its dust is very irritating to the skin and nostrils. It is not dangerous to handle even in quantities if the men are properly protected.

In general, either agent probably could be made satisfactory for most ores through careful adjustment, while the choice of agents would depend on the ore itself and on local conditions. The value of $Ca(SH)_2$ and of oils distilled with sulphur for use as reagents, however, is not to be overlooked.

Methods of Sulphidizing

Most lead ores will sulphidize either wet or dry. The use of a gas on dry, finely divided ore, however, does not appeal to the mill man. As most slime subjected to flotation is produced by wet crushing and grinding, the introduction of a soluble sulphide into the mill circuit appears to be the most practical way of sulphidizing. The use of H_2S gas, however, has been found entirely practicable; for the best results it should be introduced into a thick pulp and the pulp diluted before going to the flotation cells. This procedure eliminates the evil effects of excess H_2S and insures a more satisfactory sulphidization of the ore.

Wet sulphidizing was practiced exclusively in the mill tests on ore from the Shattuck-Arizona Copper Co., with which this paper deals in particular. The fused sulphide was dissolved and stock solution made up to a definite strength, usually between 3 and 5 per cent Na_2S by weight. During the course of the experimental work the solution was added successively to the pebble mill grinding the flotation feed (see Fig. 1), to the pebble mill's drag classifier, to the launder leading from the classifier to the dewatering cones, later to the suction of a centrifugal pump elevating the flotation feed to a Saffold agitator just ahead of the flotation cells, and finally to the cells themselves.

As the point of adding the sulphide progressed toward the flotation cells the time of contact between the reagent and the ore necessarily decreased. The time element was at first thought to be an essential factor, but proved to be relatively unimportant in treating this particular ore. Satisfactory sulphidization was obtained at all periods, as the time of contact between sulphide solution and ore was varied from twenty minutes before entering the flotation cells to zero when adding the solution directly to the head of the cells.

Intimate Mixing Necessary

An essential to sulphidize the ore in hand appeared to be a sufficiently intimate mixing of the dilute sulphidizing solution with the thickened ore pulp, in order to insure a sulphide coat for every particle of carbonate. A sufficient amount of reagent, of course, had to be available in the pulp. It is thought, though, that an appreciable period of time should be allowed for sulphidizing, such being both beneficial and desirable, especially when the limonite content of the ore is relatively high. As the solid in the flotation feed often contained 25 per cent iron, a variable portion of which was limonite and the remainder specularite, it proved a little safer and more satisfactory to add the sulphide to the Saffold machine just before the pulp went to the flotation cells. The Saffold agitator served the double purpose of assisting in sulphidizing the pulp and at the same time thoroughly incorporating the oil. The latter advantage of the use of the preliminary agitator was somewhat more apparent when using more than 1 per cent of oil.

Sulphidizable Lead Minerals

Cerussite and wulfenite sulphidize very readily. Minium, anglesite and pyromorphite slowly tarnish to a dull black in strong solutions of Na_2S, but in practice poor recoveries are made on these minerals by sulphidizing and flotation. Vanadinite and descloizite are very indifferent toward sulphide and therefore float poorly.

Cerargyrite, commonly called horn-silver, often is associated with oxidized lead and fortunately sulphidizes very readily. It is then easily recovered by flotation, concentrates as high as 2000 oz. per ton having been made in small operations. The bromide of silver also sulphidizes readily.

Interfering Elements

Certain elements, if present in the ore or associated with the lead in any way, greatly interfere with the sulphidizing operations. Probably the most important of these is manganese—especially in the form of pyrolusite—because of its oxidizing influence on the sodium sulphide. Unfortunately this mineral often is found with oxidized lead ores and is furthermore usually found in the slime portion of the mill pulp. This necessitates a separate treatment for primary and secondary slime or a great dilution of the primary with the secondary slime before satisfactory sulphidizing can take place. The soft, velvety variety of pyrolusite is probably the worst offender. Ralston and Laney of the Salt Lake City station of the U. S. Bureau of Mines have determined that compounds of manganese, basic sulphates of iron and peroxides of lead all destroy sodium sulphide. Ferrous salts in solution are classed as undesirable along with those just mentioned

because they too consume Na_2S in their precipitation as ferrous sulphide. (Sodium sulphide, being the salt of a weak acid, is highly dissociated and therefore precipitates ferrous sulphide.)

Types of Ores Suited to Sulphidizing

As with most other metallurgical processes, no hard and fast rules can be laid down as to which ores are amenable to sulphidizing and flotation. In general, those with silica and iron as the chief gangue constituents in preference to lime and alumina are likely to prove more docile. Even low percentages of manganese are very undesirable, if not prohibitive, as would be any of the other deterrents named above. Kaolinized ores are sometimes rebellious to sulphidizing and flotation, probably more through their physical effect upon the flotation than due to their chemical effect on the reagent.

The Southwest contains several lead deposits in which cerussite is the most apparent mineral, but along with this carbonate occurs variable amounts of lead in the form of pyromorphite, minetite, vanadinite or descloizite. These ores give poor returns by sulphidizing alone, and gravity and flotation usually give undesirable mixtures of little commercial value in the concentrate.

It has been said that ores high in iron would not sulphidize commercially, but such has not proved to be the case. Ores carrying most of their iron in the form of limonite of the yellow ochre variety are usually difficult to handle both from a physical and chemical standpoint.

TABLE I. LACK OF RELATION BETWEEN ANALYSES OF OXIDIZED LEAD ORES, AND THEIR FLOTABILITY

Ore	Au	Ag	Pb	Insol	Fe	S	Mn	CaO	CO_2	Al_2O_3	Zn	Remarks
1	0.02	5 8	23 9	64 7	2 5	0 0	0 0	0 1	...	.	.	Excellent recoveries by sulphidizing.
2	0 02	8 4	10 7	42 6	30 0	Tr.	.	Tr.	..	Tr.		Excellent recoveries by sulphidizing.
3	0.14	15 4	34 5	41 2	7 9	1.3		1 1	.	.		Sulphidizing failed entirely.
4	0 03	102 3	7 6	78 3	5 6	0.0	0.0			.	.	Excellent recoveries. Very little CaO and Al_2O_3. Silver in form of AgCl.
5	0 12	0 5	28 3	.	..	..	.	..	.	.	.	Poor results. Ore contained 6.1 per cent V and 8.3 per cent Cu in Cuprodescloizite.
6	0.18	15.9	4 2	73 9	1 1	0 2	0 4	4 7	5 2	4 4	7.0	Poor results by sulphidizing.
7	..	1 3	9 0	60 4	16 3	0 4	.	2 7	1.8	7 6	0.9	Excellent recoveries by sulphidizing.
8	0.01	17.9	16 5	43 3	5 3	3 2	..	3.2	2 3	21 6	5 4	Poor recoveries. Part of the lead in form of sulphide.

The chemical analysis of an ore is of little value in determining its amenability to flotation, unless it discloses interfering elements or suggests unsulphidizable compounds of lead or silver. Table I exhibits the analyses of some ores interesting in this aspect.

Legal Status of Sulphidizing

Sulphidizing, like most other metallurgical ideas, is not new. Commercial application of the idea is now being made by metallurgists who seek to increase the recovery of oxides by flotation. A complete review of the patent literature on sulphidizing, fully crediting each inventor, has been published by Rickard and Ralston.[2] Reading between the lines of this book it appears that there is no American patent covering sulphidizing with froth-flotation whose validity is not questionable.

Mill Test on Shattuck Ore

About 1000 tons of oxidized lead ore from the mine of the Shattuck-Arizona Copper Co. was concentrated during the sulphidizing tests to be described. The ore occurs in the form of a siliceous breccia, and, naturally, silica is the chief gangue constituent. Iron, mostly in the form of a black, crystallized specularite, together with variable amounts of limonite, is the other most important gangue mineral. Manganese in appreciable quantities has not been detected; lime and alumina occur only in very small amounts, and the sulphur content varies from a trace to 0.4 per cent.

Cerussite, cerargyrite and gold are the valuable minerals. The lead is practically all in the form of the carbonate, but with small amounts of the sulphate present. So far as known at present, the silver occurs in the form of the common chloride. In view of the fact that high recovery of the silver by sulphidizing was difficult to obtain and of the further difficulty of extracting this silver with hypo or cyanide, the writer has suspected at times the presence of some other form of silver.

The gold, silver and lead are apparently in no way associated or combined. The valuable minerals are of considerably greater specific gravity than the gangue, so the mineral particles larger than 200-mesh when free from gangue are readily concentrated by gravity methods. The average daily chemical analysis of the ore was: Au, 0.054 oz. per ton; Ag, 5.86 oz. per ton; Pb, 11.39 per cent; insoluble, 64.12 per cent, and Fe, 12.80 per cent.

Preliminary Laboratory Tests

Prior to the mill tests, a great many laboratory experiments were made on samples systematically taken throughout the workings in the lead orebody. Each mine sample was dried, crushed and reduced to from —80 to —200 mesh in a disk pulverizer. In a few cases the fine grinding was done in a laboratory-sized ball mill. At first the 500-gram samples used for each test were charged into agitator bottles with solutions of sodium sulphide. This chemical was used in the proportion of 6 to 12 lb. per ton of ore treated.

As the experimental work progressed the preliminary treatment was discontinued and the sulphidizing accomplished directly in the flotation cell. The dry, pulverized ore was placed in the cell with sufficient weak sulphide solution, and water added to make a pulp of 50 per cent solid. One minute of sulphidizing agitation was given before adding the oil for emulsification. After oiling the sulphidized pulp, the test machine was filled with sufficient water to make a pulp of about 25 per cent solid and the test completed in the regular manner, making both the roughing and cleaning operations on the same sample. A Janney test machine was used in the laboratory work.

[2] "Flotation," Rickard and Ralston, p. 360.

A comparison of laboratory and test mill results usually is of interest. In this case the test mill returned slightly better metallurgical results than the laboratory machines and used only about one-third the amount of Na_2S needed in the laboratory. The oil consumption also was very much less in the mill than in the laboratory. The small-scale tests, however, were very satisfactory. They clearly indicated that the finely ground ore was amenable to the proposed process and justified investigation on a commercial scale.

The Test Mill

The experimental concentrator of the Phelps-Dodge Corporation at Bisbee, Arizona, was used in making the mill tests. The flow-sheet of this mill at the time of making the tests is shown in Fig. 1. The mill was equipped with a No. 5 Telsmith gyratory breaker set to deliver ore crushed to pass a 1.5-in. ring. A Challenge feeder delivered the crushed ore to an 18-in. conveyor belt, which carried the ore over an automatic weigher to a 5-mm., round-hole trommel in closed circuit with a set of 16 x 36-in. rolls. Water added to the trommel carried the unclassified 5-mm. undersize from the trommel direct to Butchart roughing tables. The table concentrate was finished direct to the concentrate bin and the tail was dewatered in a drag

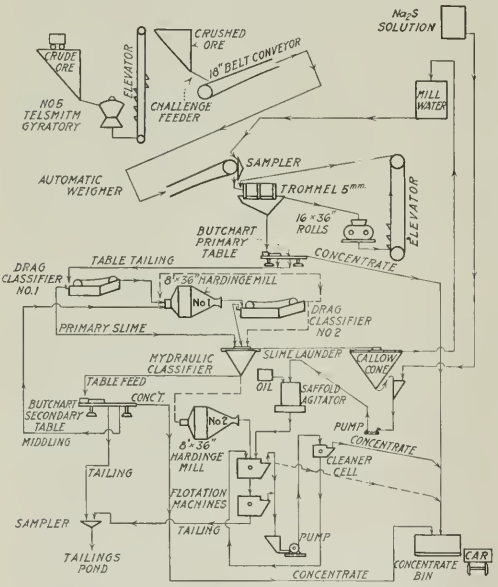


FIG. 1. FLOW SHEET OF EXPERIMENTAL CONCENTRATOR

dewaterer. Most of the primary slime was thus separated from the rest of the ore by the drag and sent through a cone hydraulic-classifier to Callow settling cones to be thickened for flotation or Senn vanner feed. The sand from the drag-dewaterer passed to an 8-ft. x 36-in. Hardinge pebble mill discharging to the cone hydraulic-classifier. The classifier sand was sent either to fine-sand Butchart tables or to another 8-ft. x 36-in. Hardinge pebble mill discharging direct to the flotation cells. The flotation section was equipped with a 10-ft. and an 8-ft. rougher and one small cleaner cell, all of the K. & K. type, and a preliminary mixer or agitator known as the Saffold machine. The ore at the head of the mill, the general concentrate mixture and the general tails of the mill were all sampled automatically. The concentrates, after sampling, were dewatered in rectangular settling tanks.

Development of Process

After the primary tables, grinding mills and desliming classifiers had been tested and adjusted to suit the requirements of lead milling, the treatment of the slimed carbonate was attempted. Even the first days of sulphidizing were quite successful in spite of the fact that far too much sodium sulphide was used and that suitable flotation oils were not available. The advantages of using less sulphide solution than in the laboratory were soon discovered. Thereafter the steps in the developing and simplifying of the process consisted mostly in selecting successively more advantageous places and methods of introducing the sulphidizing solution into the mill circuit.

At first the solution was added in excessive amounts to the feed end of the first or No. 1 Hardinge mill, as high as 15 lb. Na_2S per ton of ore being used. The mill was placed in closed circuit with the No. 2 drag-classifier, to which was sent the primary slime from No. 1 classifier. This closed circuit was made with the idea of sliming everything to flotation and at the same time giving sufficient opportunity in the pebble mill and its classifier for sulphidizing the carbonate in the primary slime as well as that in the re-ground material from the mill. All-sliming had to be given up because the pebble mill would not reduce the hard quartz in the ore to such fine sizes as required for flotation. As an expedient, the product of No. 1 Hardinge mill was deslimed in the No. 2 drag-belt, the fine sand sent to secondary tables and the primary and re-ground slimes united and sent to the Callow settling cones to thicken for flotation. The pulp in both the Hardinge mill and the No. 2 classifier, however, was found to be well sulphidized. The excess alkali due to the large quantities of Na_2S used was removed from the circuit by decanting the Callow cone overflow. The thickened product of the cones was then found to float quite satisfactorily. In this system the fine sand was being sulphidized in the mill and classifier and then sent to tables. This, of course, caused an unncessary waste of reagent, so the sulphidizing solution was added to the slime after it had been delivered from the hydraulic classifier to the launder leading to the settling cones.

The fine sand as delivered by the drag classifier contained so much slime that the secondary tables failed to make the desired recovery, so the use of the drag was discontinued. Instead, the product from No. 1 mill was combined with the primary slime and sent to a hydraulic desliming classifier, and the sulphide solution was added to its overflow. This move reduced the time of contact of the reagent with the ore, but flotation continued to give good results even with the sulphide reduced to 7 lb. a ton.

The large amount of Na_2S being used rendered the overflow from the Callow settling cones unfit for reuse in the mill circuit, so the sulphidizing solution

was next added to the spigot discharge of the settling cones. With some readjustment of oils, pulp densities and a decided reduction in the amount of Na_2S, the flotation cells continue to give a good account of themselves.

Sodium sulphide solution was added to the inlet of the Saffold agitator with satisfactory results and finally carried down the flow sheet and added directly to the flotation cells. Although good results were obtained here, the cells required somewhat closer attention and their work appeared to turn on rather fine points as to alkalinity, oils, pulp density, etc. It was evident that more consistent results could be obtained by adding the sulphide to the discharge of the Callow cones, thus allowing a few minutes' contact and insuring a thorough mixing of the pulp with the weak sulphidizing solution before reaching the flotation cells. This arrangement permitted the sulphidizing reaction to occur before the oil was added to the pulp. Such would seem to be the logical sequence, but satisfactory flotation was obtained consistently while the sulphide and oil were added simultaneously to the Saffold machine.

Flotation Oils

The oils used in flotation were for the most part mixtures of hardwood and coal creosotes with small amounts of pine or pine-tar oils in addition. With frothing creosotes no pine oil was needed. While some oils and oil mixtures did better work than others, the choice of oils was not a critical part of the process. Once the sulphidizing and flotation practice was established with experienced operators, quite a variety of oils could be used with very similar metallurgical results. An oil mixture on which much of the work was done consisted of Cleveland Cliffs wood creosote No. 1, 25 per cent; Barret creosote No. 609, 64 per cent; and Pensacola Tar & Turpentine Co. No. 350, 11 per cent. About 1.2 lb. of the mixture was used per ton of dry ore in the flotation feed. Even coal tar and fuel oil were included in some of the mixtures with satisfactory results. Good results were obtained by the use of from 17 to 20 lb. of oil of the following composition:

	Per Cent
California fuel oil	79.2
Barrett creosote No. 609	9.4
Cleveland Cliffs creosote No. 1	5.7
General Naval Stores C-15	5.7

Many other oils and combinations of oils would no doubt have given just as good results. With most oils a large flow of sulphidizing solution called for more oil, and conversely over-oiling could be remedied by increasing the flow of sulphide.

Mill Results

About 30 tons of ore were treated per day at the rate of 130 to 150 tons per 24 hours. The rate of treatment was limited for the most part by the pebble mill's ability to grind the tailings from the primary tables. The concentrator operated one shift of 8 hours per day, but considerable time was consumed in making repairs and changes incidental to experimental work and in starting and stopping the mill. The daily sampling, both automatic and hand, was not begun until all adjustments had been made and the machines appeared to be doing their best under the conditions imposed on them for the particular test in hand.

The average of the daily work of the general concentrator under a variety of conditions tested in a month is exhibited in Table II. Table III gives the results of a typical day's work but on a rather high-grade head. The concentration ratios and the percentage weights were calculated on the lead assays because the gold and silver values were difficult to sample and assay accurately.

Work of Primary Tables

The Butchart primary tables gave a very satisfactory performance both in point of recovery and capacity. A single table satisfactorily handled 150 tons of —5 mm. feed per 24 hours, recovering 55 to 70 per cent of the total lead and about 45 per cent of the silver in its feed. This was crushed by rolls to pass a 5-mm. round-hole trommel and was neither deslimed nor classified before going to the table. From 8 to 16 per cent of the primary table feed was —200 mesh. The tables were equipped with Butchart progressive pitch riffles $\frac{9}{16}$ in. deep at the feed-end, sloping to $\frac{5}{16}$ in. at the concentrate discharge end. The tables were set for a $\frac{3}{8}$-in. stroke and made 275 strokes per minute. The average work of the primary tables is exhibited in Table II.

Work of the Secondary Tables

The secondary or fine-sand tables accounted for 9.1 per cent of the total lead in the original ore delivered for a month to the head of the mill, and 80 per cent of the gold, 47.5 per cent of the silver, and 71.6 per cent of the lead in their own feed. They handled from 40 to 60 tons of fine, deslimed sand per 24 hours, the spigot product of a hydraulic classifier. The average feed to these tables for a month contained 0.05 oz. Au, 4.9 oz. Ag, 4.38 per cent lead, 78.4 per cent insoluble and 9.6 per cent Fe. From 5 to 8 per cent of this feed was —200-mesh slime which should have been removed by the desliming classifier. The tables did good work on the fine sand but of course did not recover anything from the —200-mesh slime.

The table middling, containing about 0.05 oz. Au, 5 oz. Ag, 4 per cent Pb, 68 per cent insoluble and 17 per cent Fe, was returned to the Hardinge mill.

The greatest silver loss on the secondary tables was in the +48- and +65-mesh sizes, indicating that finer grinding might free more silver and thus help the recovery. The average daily work of these tables is shown in Table II.

Flotation Results

Flotation recovered about 20 per cent of the total Au, 6 per cent of the Ag, 15 per cent of the Pb, and 8 per cent of the iron in the original ore as delivered to the mill. The flotation section was equipped with two K. & K. machines with 8-ft. x 28-in. and 10-ft. x 28-in. rotors respectively, and during the latter part of the experimental work with a special cleaning cell with a 4-ft. x 12-in. rotor. The two large machines in series satisfactorily handled 127 tons of dry feed per 24 hours and averaged about 50 tons with an attendant recovery of 84.5 per cent of the Pb, 41 per cent of the Ag with 77 per cent of the Au in their own feed.

TABLE II. MONTHLY AVERAGE OF DAILY RESULTS

	Product	Rate Tons 24 Hrs.	Au Oz. per Ton	Ag Oz. per Ton	Pb Per Cent.	Insol. Per Cent.	Fe Per Cent.	Per Cent.
Primary Tables.	Head	147.486	0.063	5.82	14.09	58 70	14.18	100.000
	Conc't.	33.261	0.124	12.91	45.15	11.70	18.21	22.552
	Tail	114.225	0.042	4.05	5.16	.....	.....	77.448
	Per cent recovery unit	.....	60.64	42.57	71.74	.....	.....	.....
	Per cent recovery general head	.....	.....	.....	71 74	Ratio of Concentration 4 56		.....
Flotation	Head	58.140	0.048	2.87	5.92	57.32	21.37	100.000
	Conc't	7.028	0.239	9.72	44.04	13.37	18.32	12.088
	Tail	51.112	0.012	1.88	0.98	.....	.....	87.912
	Per cent recovery unit	.....	77.19	40.86	84.84	.....	.....	.....
	Per cent recovery general head	.....	.....	.....	13.92	Ratio of Concentration 8.71		.....
Secondary Tables.	Head	60.801	0.053	4.94	4.38	78.36	9.57	100.000
	Conc't	5.121	0.193	26.08	36.78	11.48	27.25	8.423
	Mid	.....	.....	.....	.....	.....	.....	.....
	Tail	55.680	0.014	2.71	1.31	.....	.....	91.577
	Per cent recovery unit	.....	79.99	47.54	71.56	.....	.....	.....
	Per cent recovery general head	.....	.....	.....	9.10	Ratio of Concentration 12.85		.....
General	Head	147.486	0.063	5.82	14.09	58.70	14.18	100.000
	Conc't	45.016	0.177	13.69	43.61	12.91	20.57	30.435
	Tail	102.470	0.014	2.32	1.25	.....	.....	69.565
	Per cent recovery unit	.....	.....	.....	.....	.....	.....	.....
	Per cent recovery general head	.....	84.31	70.67	93.86	Ratio of Concentration 3.369		.....

Sodium Sulphide—2.6 lb. ton dry flotation feed; 1.168 lb. ton dry mill feed.
Water—508.19 gal. per ton dry ore milled.
Power—19.25 kw.-hr. per ton dry ore milled.

TABLE III. RESULTS OF A TYPICAL DAY'S WORK

	Product	Tons 24 Hours	Au Oz. per Ton	Ag Oz. per Ton	Pb Per Cent	Insol. Per Cent	Fe Per Cent	Per Cent
Primary tables..	Head	155.28	0.07	6.2	15 1	55 6	15.7	100.00
	Conc't	39 69	0.16	15.9	43.7	10.6	22.1	25.56
	Tail	115.59	0.04	2.9	5.27	67.2	16.4	74.44
	Per cent recovery unit	.....	57.2	64.9	74.0	.....	.....	.....
	Per cent recovery general head	.....	.....	64.9	74 0	Ratio of Concentration 3 91		.....
Flotation	Head	55.81	0.04	2.2	6.1	60.3	19.5	100.00
	Conc't	10.08	0.18	4.7	29.7	12.2	31.6	18.06
	Tail	45.73	0.01	1.6	0.9	.....	.....	81.94
	Per cent recovery unit	.....	79.4	41.4	87.9	.....	.....	.....
	Per cent recovery general head	.....	.....	5.2	12.7	Ratio of Concentration 5.5		.....
Secondary tables	Head	59.78	0.04	3.6	4 5	78.6	8.9	100.00
	Conc't	4.10	0.45	15.8	42.6	15.3	17.9	6.85
	Mid	.....	.....	.....	.....	.....	.....	.....
	Tail	55.68	0.01	2.7	1.7	.....	.....	93.15
	Per cent recovery unit	.....	76.7	30.1	64 8	.....	.....	.....
	Per cent recovery general head	.....	.....	6.7	7.4	Ratio of Concentration 14.6		.....
General	Head	155 28	0 07	6 2	15 1	55.6	15.7	100.00
	Conc't	53 87	0.18	13.7	40.7	12.5	23.4	34.69
	Tail	101.41	0.01	2.2	1.5	.....	.....	65.31
	Per cent recovery general head	.....	90.8	76.9	93.50	Ratio of Concentration 2.89		.....

Ore—From 2, 3, 6.
Flow Sheet—Saffold machine made a froth concentrate and oiled sulphidized the pulp for the K. & K. machine in series.
Na_2S—0.692 lb. per ton mill feed dry (1.924) per ton flotation feed added to feeder box to Saffold machine).
Oil—0.367 lb per ton dry mil feed. 1.022 lb. per ton dry flotation feed.
Tons in this run—43.59.

TABLE IV. FLOTATION EXPERIMENTS

No.	Experiment	Oil	Na_2S Lb. per Ton	Ratio of Conc.	Pulp Per Cent H_2O	Per Cent Sol.		Tons in 24 Hours	Assay Au	Assay Ag	Assay Pb	Assay Insol	Assay Fe	Weights per Cent
1	Low Na_2S consumption	Cleveland Cliffs Wood Creosote No. 1, 25% Crude creosote....64% P. T. & T. Co. No. 350..... 11%	1.2	11.45	79.42	20.58	Head	54.13	0.04	2.0	5.4	61.0	21.2	100.00
							Conc't	4.78	0.20	5.4	52.4	11.8	11.5	8.83
							Tail	49.35	0.01	1.6	0.9	....	....	91.17
							Per cent rec...	.....	78.9	28.4	84.75	....	....	.....
2	Flotation roughing and cleaning to produce high-grade concentrate	Barrett No. 609, 76.4% U. N. S. C-15, 18.2% P. T. & T. Co. No. 350 ..... 5.4%	1.5	13.71	66.0	34.0	Head	60.68	0.04	2.6	5.4	54.8	24.4	100.00
							Conc't	4.42	0.10	10.2	65.1	3.5	5.9	7.30
							Tail	56.26	0.02	2.0	0.7	....	....	92.70
							Per cent rec....	.....	62.4	28.7	88.0	....	....	.....
3	Using bulk oil ..... Note—Same results were obtained with 2.8 lb. Na_2S per ton	Fuel oil.....79.2% Barrett No. 609, 9.4% C.C.W.C. No. 1, 5.7% U.N.S. No. C-15, 5.7% Using 18 lb. per ton	5 01	6.32	65.47	34 53	Head	56.04	0.05	2.7	7.8	62.2	17.0	100.00
							Conc't	8.90	0.14	8.7	46.1	14.3	16.9	15.83
							Tail	47.14	0.01	1.6	0.6	....	....	84.17
							Per cent rec....	.....	95.8	49.9	94.8	....	....	.....
4	High Na_2S with thin pulp	Barrett No. 609, 60% U.N.S. No. C-15, 40% 1 lb. per ton of dry feed.	4 68	6 87	79.8	20.2	Head	52.90	0.04	2.2	9.4	66.3	12.6	100.00
							Conc't	7.70	0.16	6.3	58.1	11.2	8.3	14.56
							Tail	45.20	0.01	1.5	1.1	....	....	85.44
							Per cent rec....	.....	80.0	41.7	90.0	....	....	.....
5	All-sliming flow sheet.	C.C.W. C. No. 1, 40% Barrett No. 609, 60%	3.23	8.97	67.02	32.98	Head	127.60	0.03	6.0	6.7	65.3	15.7	100.00
							Conc't	14.23	0.19	38.7	53.7	14.3	9.8	11.15
							Tail	113.37	0.01	1.9	0.8	....	....	88.85
							Per cent rec....	.....	70.4	71.9	89.4	....	....	.....
6	Ore high in Fe..... One 10-ft. K.&K. machine taking total feed from Saffold machine.	C.C.W.C. No. 1, 25% Crude creosote, 64% P.T.&T. Co. No. 350..... 11%	2.0	9.47	73.4	26.6	Head	51.16	0.06	2.2	4.6	52.3	26.0	100.00
							Conc't	5.40	0.34	6.3	35.1	11.6	35.4	10.56
							Tail	45.76	0.02	1.9	1.0	....	....	89.44
							Per cent rec	.....	70.8	19.5	80.6	....	....	.....
7	Low-grade lead ore....	C.C.W.C. No. 1 18% Crude creosote...73% P.T.&T. Co. No. 350..... 9%	2 2	12 19	68.0	32.0	Head	43.86	0.045	2.3	3.0	73.2	13.6	100.80
							Conc't	3.60	0.22	9.8	32.1	28.5	18.4	8.20
							Tail	40 26	0.01	1.2	0.4	....	....	91.00
							Per cent rec..	. . .	81.5	54.5	87.8	....	....	.....

One 10-ft. machine alone handled 50 tons in several tests but the tails consistently assayed a few tenths per cent of lead higher than when two machines were running in series. Even with a large reduction in tonnage one 10-ft. machine alone would not produce as low a tail.

The 4-ft. cleaning machine appeared to raise the grade of the combined concentrates from the two roughing machines about 10 points without affecting the tailing loss of the second machine in the series. The concentrate from the first rougher in series was usually sufficiently high-grade so that it did not require cleaning. In most of the tests only the froth from the second machine in the series was retreated in the cleaner.

The feed to the flotation machines was 97 per cent —200 mesh. It contained between 4 and 5 per cent of Pb, 2 to 3 oz. Ag per ton, 16 to 21 per cent of Fe and about 62 per cent insoluble. About half of this silver was recovered and no more silver was recovered after a strong sulphidizing treatment than after a weak one. Just why a higher recovery of the silver by flotation was not obtainable has not been determined. Senn vanners and slime tables failed to make any further recovery of either silver or lead from the flotation tail.

The finished flotation concentrate under the best conditions was quite clean. One day's work, for example, assayed 0.10 oz. Au, 10.2 oz. Ag, 65.1 per cent Pb, 3.5 per cent insoluble and 5.9 per cent Fe. Especially during the early part of the testing no special effort was made to obtain high-grade concentrate from the flotation cells. The daily average of all tests made during one month is shown in Table II. This average, of course, includes many days on which unfavorable conditions were imposed on flotation purely as a matter of experiment. Table IV shows the work of flotation under different conditions.

In one test an attempt was made to slime the entire tail of the primary tables by two-stage grinding in two 8-ft. x 36-in. Hardinge mills. The use of the secondary tables was discontinued. Their usual feed was reground and sulphidized in the second mill, then discharged directly into the first flotation machine in the series along with the primary slime and that produced by the first Hardinge mill. The discharge of the second mill contained 6.3 per cent +65 mesh and 54.3 per cent —150 mesh. The results of flotation for the day are shown in Test 5, Table IV.

Chemical Consumption

The usual consumption of 100 per cent Na_2S per ton of dry slime treated by flotation was about 2.6 lb., ranging from 1.5 to 15 lb. With 4.5 per cent lead ore, 2 lb. usually gave good results. In terms of the commercial 60 per cent Na_2S this would be equivalent to 3.3 lb., costing about 10c. with cheap sulphide, or about 17c. with sulphide at war prices. Sodium sulphide sells in normal times for about $1.85 per 100 lb. of 60 per cent Na_2S f.o.b. factories in the East. At present, from $3.00 to $3.50 per 100 lb. in car lots is asked in New York and on the Pacific Coast. Thus the cost of sulphidizing need not exceed 17c. per ton even under unfavorable conditions. The manufacture of Na_2S at the mill is not at all impossible under favorable conditions, but in this respect H_2S probably has the advantage.

Rapid and accurate analytical methods based on iodometry have been developed for the control of sodium sulphide solutions. A cheaper means of control is afforded by the use of hydrometers, following the practice of alkali manufacturers.

For each pound of lead carbonate recovered about 0.02 lb. Na_2S was consumed. Theoretically 0.29 lb. Na_2S is required to convert completely one pound of lead in the form of carbonate to the sulphide PbS. At the rate of 2.6 lb. Na_2S per ton of 5.92 per cent lead ore with 84.8 per cent recovery, it may be calculated that only 6.9 per cent of the theoretical Na_2S suffices for sulphidizing for flotation on a favorable ore. It is obvious that the sulphide coating produced on the carbonate particle must be very superficial under the conditions just given, which were those obtaining in the test mill. Even with its very thin coating of sulphide the carbonate was a brilliant blue-black. The concentrate coming from the flotation machines appeared much the same as a rich galena concentrate. The black appearance of the froth changed to a dull maroon color when the ore in the pulp contained much iron, but the grade of the concentrate remained much the same. About 99 per cent of the concentrate from the flotation cells was —200 mesh. Operation of the cells was easier and low tails were more consistently obtained on feed consisting of all —200-mesh material than on pulp containing mixed sand and slime.

Future of the Process

Sulphidizing is not offered here as a panacea for all lead carbonate troubles. On the contrary it has failed almost completely in some instances, due either to elements interfering with the sulphidizing, to difficulties inherent to flotation, or to both.

For ores consuming or destroying relatively large amounts of chemicals, cheap reagents must be had if the process is to be commercial. The manufacture of H_2S from oil and sulphur is a step in this direction. Other methods for the production of sulphidizing agents are being investigated. Combinations of reagents offer possible advantages in some instances and sulphidizing in combination with leaching and precipitation methods offers possibilities.

Although doctors disagree as to the probable application that sulphidizing will have in ore dressing, one thing is certain—the last word has not been said.

Shattuck-Arizona Copper Company,
Bisbee, Arizona.

A waterproof coating for airplane propellers, which incorporates thin aluminium leaf in the finish, was developed by the Forest Products Laboratory at Madison, Wisconsin, and placed in production by the War Department. The process is practically 100 per cent effective in preventing absorption of water, particularly in the storage stage. A French authority states that 80 per cent of the French propellers produced are rejected by the pilots mainly because they are out of balance. This difficulty is due largely to unequal absorption or distribution of moisture and can be greatly reduced by an effective waterproofing coating.

Fuel Economy in the Boiler House—I

Study and Importance of the Heat Losses in Boiler Plants and Their Control — Automatic Flue Gas Recorders and Details Regarding Gas Sample Conduits, Tubes, Stopcocks, Soot Filters and Water-Jet Pumps

By JOHN B. C. KERSHAW

THE call for efficiency in the working of steam boilers was never more urgent than at the present time, when the outlay upon fuel forms such an important item of manufacturing costs in all our staple industries. Whatever the basis of the political settlement may be, the end of the war will not mean a return to the status quo ante with regard to fuel, and it is in the highest degree improbable that coal mined in Europe and America will ever return to its pre-war low level of value.

The subject of fuel economy will therefore not cease to be of importance when the war ends, but will remain equally urgent in the strenuous years of industrial competition that are ahead. Power users, consequently, both on grounds of personal profit and public interest, ought to study the question of fuel economy in the boiler house, for it is here that the greatest waste of fuel is occurring in connection with manufacturing industries.

Heat Losses in the Boiler Plant and Their Control

Figs. 1 and 2 are curve diagrams, showing the various heat losses in two typical boiler plants, both burning the same fuel—a bituminous slack testing 13,500 B.t.u. —one badly managed and the other well managed. From these diagrams it can be seen that the heat units carried away by the waste gases account for the larger proportion of the loss in both cases and that the best chance for reducing this loss lies in the strict control of the temperature and volume of these escaping gases.

The importance of the regular testing of the waste gases passing away from boiler plants lies in the fact that only by chemical tests can one judge of the dilution of the gases and whether a great excess of air is being

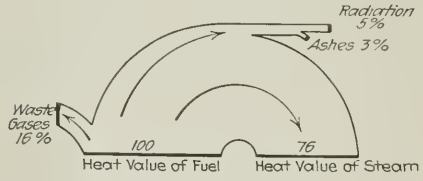


FIG. 1. EFFICIENCY DIAGRAM FOR A WELL MANAGED BOILER PLANT

passed through the furnaces. If no tests are made, the engineer in charge of the plant is absolutely in the dark as to the course of the combustion process. The waste gases, however, carry with them to the chimney a large proportion of the heat energy of the original fuel, and if the volume of these gases be unnecessarily increased, the proportion of heat lost in this way is doubled or even trebled. Efficiencies of 70 per cent and over can be attained in the boiler plant only when the heat losses in the waste gases have been reduced to a minimum (1) by cutting down their volume and (2) by reducing their temperature to the lowest point compatible with the maintenance of the required draught at the base of the chimney.

As regards the percentage of heat that may be quite easily lost with the gases escaping to the chimney with varying percentages of carbon dioxide, the following table is instructive:

Percentage of CO_2 in Waste Gases	Percentage of Heat Lost — Temperature of Waste Gases		
	400 Deg. F.	500 Deg. F.	600 Deg. F.
4	32 40	40 50	48.60
6	21 80	27.30	32 80
8	16 40	20 80	24.90
10	13 40	16 80	20 20

The losses range, therefore, from 13.4 per cent of the total heat (which may be regarded as the minimum possible when natural draught is used) up to 48.6 per cent, or nearly one-half the heat produced by combustion of the coal.

It may be objected that the latter limit is seldom reached in practice. The writer has made many tests upon boilers worked without scientific control, the exit gases from which showed only 4, 5 and 6 per cent CO_2, and he is convinced that heat losses to the chimney equivalent to one-third of the fuel burned in the boiler furnaces are quite common in practice. The scientific control of boilers, therefore, demands regular and systematic examination of the waste gases.

Automatic CO_2 Recorders

It is now about fifteen years since automatic CO_2 recorders first made their appearance. For a time they

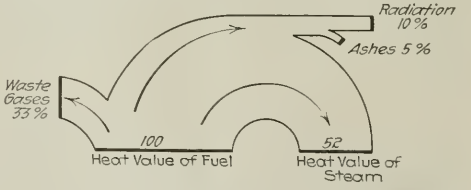


FIG. 2. EFFICIENCY DIAGRAM FOR A BADLY MANAGED BOILER PLANT

enjoyed great popularity, and were to be found in all boiler houses where the engineers prided themselves on being alive and up to date. The difficulties met with in keeping the apparatus in good working order, however, were considerable, and as the recorders failed to satisfy the demands made upon them, they were discarded by many engineers who at first were most loud in

their praise. Their failure was due not so much to defects in the apparatus, though no doubt some of them were unnecessarily complicated, as to defects in their installation and in their methods of use.

In the first place, the pipe connections between the automatic gas-testing apparatus and the boiler flues were made too long and had too many joints, with the result that air leakage occurred and in some cases the pipes corroded up. Another common cause of failure was the blocking of the filter used to remove the soot and moisture from the gases before they were tested; but the most general cause of failure was the placing of the apparatus in charge of an engineer or stoker who had had no previous training or experience in the care of delicate mechanism or glass apparatus.

The Causes of Trouble

To deal with these causes of trouble in order, the connecting pipe from the recorder to the individual boiler flues should never exceed 30 ft. in length and should be constructed, not of iron or lead, but of 6-ft. lengths of glass tubing, ½ inch in external diameter, joined to-

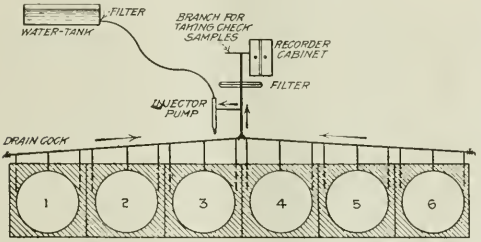


FIG. 3. DIAGRAM OF GAS CONNECTIONS FOR A BATTERY OF SIX LANCASHIRE BOILERS

gether with couplings of the best red rubber, wired on. An engineer would, of course, specify metal tubing with screwed joints for this purpose[1], but as a chemist with some practical knowledge of the subject of gas sampling and testing under works conditions, the writer believes firmly in the advantages offered by glass over metal. In the first place it is non-corrodible and in the second place one can see when cleaning out is required, whereas with metal tubes one is absolutely in the dark as to the state of the interior. Gas-testing apparatus ought, therefore, always so far as possible to be constructed of glass, for the two advantages of non-corrodibility and transparency far outweigh all the disadvantages attached to the use of a fragile material, and with care, glass apparatus and tubing can be used for years without renewals of any kind, except at the joints. These joints will require attention, but if good rubber be used they will last six months or more, though they should be renewed at once when the rubber begins to crack.

Tubes and Stopcocks

At each branch to the boiler, or to the main flue, a glass stopcock and T piece must be inserted in the line, with the longer leg pointing vertically downward. The tube that actually passes into the flue is attached to this leg, and must be of ⅝-in. external diameter hard "potash" glass in order to withstand temperatures up to 800 deg. F. without softening or melting. These dependent tubes, where they pass through the brickwork of the boiler setting, should be protected by flanged iron guard tubes ¾ in. or 1 in. diameter, and should be fixed firmly in these with the aid of cork bungs. The glass stopcocks must be regularly cleaned and greased, and once a week the tightness of the whole system of connecting tubes must be tested by closing all the stopcocks and working the water-jet air pump until a vacuum of 8 in., as registered by a gage connected to the line near the pump, is attained. Should this be impossible, the leakage that destroys the vacuum must be sought for and stopped. At frequent intervals the dependent tubes that pass into the flues, also the main length of connecting tube, must be freed from internal soot and dust by the aid of low-pressure steam or by flushing with warm water, the hard glass tubes being withdrawn from the flues and cooled before this treatment is carried out.

One Recorder to Six Boilers

It is advisable to have a recorder installed for every six boilers and to be able to connect this as desired to the flue from either the right or left hand boiler fire (in the case of Lancashire boilers) and to the main flue behind each boiler. (See Fig. 3.) This gives a maximum of eighteen connections on any one line. The cabin or cupboard in which the apparatus is installed should be placed centrally, so that three of the boilers are on one side of it and three on the other. The tubes should be laid with a fall away from the central connection to the recorder, in order that the moisture that condenses in the line may be removed at frequent intervals of time by opening the end stopcock of each branch.

Design of Soot Filter and Water-Jet Pump

The soot filter may be constructed of sheet lead (although a glass one constructed on the laboratory "desiccator" principle would be better) and should be placed close to the recorder, so that there is only one filter on each connecting line, and this can then be kept under constant observation. It must be of the circular flat shallow type, which gives a large filtration area with a small cubical capacity, in order that there may be less "lag" in the test records. The joint between the two halves of the filter is made with a rubber gasket-ring and two external rings of hard lead or iron, provided with bolts and thumbscrews. Glass-wool or asbestos-felt supported on wire gauze is used as the filtering medium; this must be removed and renewed daily or oftener, according to the amount of soot contained in the waste gases. The advantage of placing the filter close to the recorder is that only the gas actually tested is passed through it, whereas if it be placed upon the main connecting line all the gas withdrawn by the pump from the flues will pass through it and it will require cleaning much more frequently.

When an ejector type of water pump is used to abstract the gas from the flues it is advisable to provide a separate water supply tank, fitted with a filtering attachment to retain fine particles of grit and other matter which might stop up the jet of the air pump and cause it to cease working. A steady pressure or head of water is also required in order to obtain satisfactory operation with this type of pump; this is most

[1]See "Sampling and Analyzing Flue Gases," by H. Kreisinger and F. K. Ovitz, Bureau of Mines Bull. 97 (1915).

easily arranged for by installing a separate supply cistern with a floating ball-tap and lead run-off pipe.

Automatic and continuous CO_2 recording apparatus falls into two broad classes, according as the percentage of carbon dioxide gas is measured by direct absorption in caustic potash or some physical characteristic of the gas that is a criterion of the CO_2 contents is observed and measured. In the article following, descriptions and illustrations of all the well-known types will be given. In closing this introductory article, however, it is well to emphasize the great importance of regular and systematic chemical examination of the waste gases in boiler plants, and to urge that the care of any automatic testing instruments installed should be placed in the hands of specially trained men, and not left to the charge of ordinary stokers or shift-engineers who may happen to have a few spare minutes available or may volunteer for the job. Many past failures with such instruments in the boiler house are undoubtedly attributable to the neglect of this latter precaution, and some engineers have made the same mistake with these machines that they made at first with mechanical stokers, and have imagined that as they were automatic in action they did not require skilled attention. The lesson of experience, however, is that automatic apparatus of all kinds demands a well-trained and highly intelligent man to look after it and to keep it in order; and that the most certain way of asking for trouble in the boiler house is to place insufficiently trained men in charge of mechanical stokers and carbon dioxide recording apparatus. When this lesson has been thoroughly learned by chief engineers, the automatic types of CO_2 apparatus will once more come into favor, for with intelligent and skilled attention they can be of the greatest service in maintaining the conditions requisite for high efficiency in the combustion of coal under steam boilers.

Electric Pig Iron After the War

By Robert Turnbull*

At THE meeting of this society held in Pittsburgh in October of last year I read a short paper on the manufacture of low-phosphorus pig iron from scrap shell turnings in the electric furnace. At the time that paper was read this industry was only in its infancy, the total output in Canada being only about 900 tons per month. Today Canada's output is more than 2500 tons, and by the latter part of November the production will be between 4000 and 4500 tons per month. Furnaces are operating at Orillia, Ont.; St. Catherines, Ont.; Collingwood, Ont.; Belleville, Ont.; Hull, Que., and Shawinigan Falls, Que., the two largest producers being St. Catherines and Orillia, where the output per furnace is about 700 tons per month. Furnaces are building in Lakefield, Ont.; Shawinigan Falls, Que., and Vancouver, B. C., the iron produced in all these furnaces to be used for Canadian consumption with the exception of the production of the Vancouver plant, a portion of which will be exported. Canada at the present time is almost entirely dependent on its supply of low-phosphorus iron from electric furnaces, its usual supply of blast-furnace iron from the United States being shut off.

A number of improvements have taken place in tbe manufacture of this iron since I read my former paper. The consumption of electrode has been reduced, some months showing 21 lb. to the gross ton of iron. Kilowatt-hours also have been reduced, the average practice showing slightly more than 500 to the gross ton. Ferro-silicon has been replaced by another product, which reduces the cost and helps the carbon addition. The carbon in the iron is seldom below 3 per cent, and in quite a number of heats 3½ per cent is attained. The cost of producing the iron has gone up, mainly owing to higher labor cost and a general increase on all raw materials, including shell scrap; these items, with the exception of scrap, having increased more than 50 per cent since the Fall of last year.

The following table of 25 consecutive heats shows very clearly the quality of iron being produced today, also the great improvement in the carbon contents:

ANALYSIS OF 25 CONSECUTIVE HEATS

Heat Number	Silicon[1], Per Cent	Sulphur, Per Cent	Phosphate, Per Cent	Manganese, Per Cent	Carbon, Per Cent
254	1 02	....	0.016	....	3.42
255	1 10	....	0.019	0.70	....
256	1 15	0.023	0.017	....	2.77
257	1 40	....	0 015	....	....
258	1 18	....	0.019	0 70	3.21
259	1 10	0.020	0 013	....	....
260	1 10	0.016	0.021	....	3.32
261	1.06	....	0.018	0 70	....
262	1.00	0.019	0.016	....	3.17
263	1.07	....	0.013	0.74	....
264	1.20	0.012	0.015	....	3.48
265	1.28	....	0.017	0.75	....
266	1.12	0 011	0.021	....	3.07
267	1.00	....	0.014	0.74	....
268	1.02	0.010	0.014	....	3.09
269	1.02	0.011	0.039	....	3.18
270	1.28	....	0.032	0.69	3.36
271	1.07	....	0.032	....	3.05
272	1.10	0.009	0.021	....	3.10
273	1.20	....	0 030	0.68	2.93
274	1.72	....	0.022	....	3.21
275	1.12	0.012	0.028	0.66	3 40
276	1.02	....	0 027	....	3.22
277	1.25	0.010	0.013	....	3.18
278	1.42	....	0.014	0.66	....
Aver. analysis,	1 16	0.014	0.020	0 70	3.19

[1]Silicon desired, 1.00 to 1.25 per cent.

Having been asked by the president of this society to give my views on what will be the probable use of furnaces at present engaged in the production of low-phosphorus iron in after the war problems, I will endeavor to do so, although I consider any statements made at present will be in themselves problematic, as they will depend entirely on the state of trade after the war, which at the present time no one can foresee.

Quality Near That of Blast-Furnace Iron

First of all, the class of iron produced in these furnaces today has not been considered by the consumer to be equal to the grade of iron formerly received from blast furnaces, and, if this is correct, the tendency of the consumer would be to return to blast-furnace iron when he can obtain it. My answer to this is, that the iron produced today in the electric furnace is now so close in quality to blast-furnace iron—it now being possible to attain from 3 per cent to 3½ per cent carbon in this iron—that by the time the consumer will again be able to import iron from the United States he will have become so accustomed to using electric-furnace iron that the deciding factor will be the question of price.

The next question is: Will specifications on steel

*Paper read at the thirty-fourth general meeting of the American Electrochemical Society in Atlantic City, N. J., Oct. 1, 1918. This paper was read prior to the signing of the armistice. The production figures are, therefore, probably erroneous at this time, but the technique and economics of the process are still pertinent.—Editor.

produced after the war, which at the present time allow very high limits for phosphorus and sulphur, be reduced to their former strict limits, which were 0.04 for both phosphorus and sulphur? This issue will have an important bearing on the manufacture of iron in the electric furnace, as should these limits be reduced to their former level, it will be impossible for the steel manufacturer to use the bessemer grade of iron, which he mixes with the low-phosphorus pig, to such an extent as he is doing today, and he will be obliged to use a very much larger quantity of low-phosphorus pig—possibly 100 per cent more. As it is not likely this extra tonnage can be obtained for years to come from the United States, the only source of supply would be the present electric-furnace product. Should, on the contrary, the present high limits be retained the question of price between the two classes of iron would be the determining factor to the consumer, provided the States will be in a position to supply Canada with its requirements in this grade of iron.

Question of Supply Considered

The next question, and what may be considered the most important one, is: Where will the electric furnaces obtain their supply of low-phosphorus scrap turnings when the present source no longer exists? This brings up another question which will be quite a determining factor in solving the problem, and that is: Will the open hearth continue the use of turnings in the charge, as is being done at present?

I think we are safe in considering that the open hearth will discontinue the use of turnings as soon as it can obtain its supply in heavy melting scrap, as the use of turnings in this furnace involves a greater use of pig iron, and there is a much higher melting loss when turnings are used as compared with heavy melting scrap. This loss is not taken into consideration so much at present, owing to the high prices obtained for the finished product and the impossibility of getting enough heavy melting scrap, but more attention will be paid to this when normal competition again sets in.

Before the war a considerable tonnage of steel turnings was available, and as the production of steel in Canada is now at least 100 per cent more than before the war, we may consider that a very much larger quantity will be produced after the war. Eliminating the open hearth as a consumer, this scrap will become, so to speak, a drug on the market, as it was formerly, and the electric furnace, as a low-phosphorus iron producer, will be the natural customer for this scrap. By paying a small bonus on low-phosphorus turnings, machine shops would no doubt be willing to grade their scrap, as they are doing at present with shell turnings, and this would be a complete answer to our question, provided such conditions could be realized.

We must, however, consider the possibility of an insufficient supply of such turnings and what we would expect to do in such a condition. This would bring us back to the old question of smelting ore in the electric furnace, as this would be the only other source of supply left, if the present furnaces were to be used for the production of low-phosphorus iron. Former experiments have shown that iron ore and steel turnings, mixed in certain proportions, give a production very favorable in proportion to the amount of power used, and smelting operations are very easy to handle. The furnace which would be used to smelt such a mixture would be of the continuous type, with a load factor approaching 100 per cent, and, as electric steel furnaces have a very low load factor—in some cases not over 50 per cent—the amount of extra power necessary to produce the same quantity of iron from a mixture of ore and steel turnings, as compared with our present type of furnace melting scrap alone, would not be considerable.

About 1400 kw.-hrs. are required to produce one gross ton of iron from a mixture of 50 per cent metallic in turnings and 50 per cent iron ore, so that our present furnaces, which are of 1200 kw. capacity, could produce 20 tons per day of iron, as compared with from 25 to 30 tons using steel turnings alone. I am not prepared to say how the cost of the iron would compare in the case of the mixture as compared with steel turnings alone, but as no ferrosilicon or fluorspar would be required, and the return in metallic contents charged would be 100 per cent as against 90 per cent with turnings alone, besides a great saving in furnace repairs, this would probably more than compensate for the extra power, electrodes and carbon necessary for the reduction of the ore.

A mixture of this kind permits the use of iron-ore concentrates, the charge being kept porous enough, owing to the presence of the turnings, and as these concentrates can be obtained very low in phosphorus, they could be used to advantage in the production of low-phosphorus iron and permit the use of turnings with higher phosphorus contents. As the operation would be conducted in a reducing atmosphere, the resulting carbon in the iron would be perfectly comparable to the blast-furnace product.

Another use to which the present furnaces could be put would be the melting of iron for foundry purposes. The war having eliminated the exportation of English iron and also iron from the United States, foundries have faced the necessity of confining themselves entirely to Canadian iron, mixed with a very high percentage of scrap cast iron, and, it must be confessed, with good success. As most of the plants which are producing low-phosphorus iron would be suitable for foundry purposes, and as the grade of iron can be controlled very closely and silicon added at little cost, there should be an excellent opening for these furnaces in replacing the cupola for melting purposes, and using nothing but the cheapest cast-iron scrap, including borings, etc., and the metal used direct from furnace to molds, without the use of any pig iron whatever.

A New Bronze-Alloy in Norway

A captain in the Norwegian Navy has invented a new bronze-alloy, the so-called M. bronze, which is particularly adapted for bearings, armaments and machinery parts where a comparatively high hardness is required, and for welding and rolling, according to the weekly bulletin of the Canadian Department of Trade and Commerce. In order to satisfy different requirements the bronze is worked out in three qualities, hard, medium hard, and soft. For use where an especially good quality is demanded and for ships' use there can also be produced a finer quality, like mangan bronze.

Pittsburgh Meeting of the American Ceramic Society

New and Important Data Presented on Graphite, Bonding Clays, Porcelain and Optical Glass—Comparative Properties of Foreign and Domestic Graphites — Tests Under Foundry Practice—Microscopic Studies of Porcelain—Gases Dissolved in Optical Glass

THE subjects covered by the term "ceramics" seem to include about everything from bricks to bric-à-brac; but the crowd that is back of the subjects is one to be respected. The Pittsburgh meeting of the American Ceramic Society was the twenty-first annual assembly; and President Homer F. Staley in his official address, in opening the program, noted that this meeting was of significance in that it represented the twentieth birthday of the society. He then went on to note some of the past work of the society, as well as some of the desirable policies for the future. Among some of the changes he recommended for consideration:

1. The enlargement of the publication activities of the society, in some increased work of the *Journal* of the American Ceramic Society.

2. The employment of a full-time secretary who should also give his full attention to the editorship of the *Journal* and business management of the society.

3. The selection and establishment of permanent headquarters for the society, in some one of the leading cities of large commercial activity and opportunity in the country.

4. The enlargement of the voting membership of the society, and the possible merging of the "associate" membership with the "active" membership.

5. The consideration of the status of the cement and mortar industries, in closer relations with the work of the society.

The report of the secretary, Professor Charles F. Binns of Alfred University, who is perhaps the dean of American ceramics, showed the satisfactory financial condition of the society, and recommended the appointment of standing committees on the following subjects, which roughly would seem to include the more important branches of ceramics:

1. Glass. 2. Enamel. 3. Pottery and porcelain. 4. Refractories. 5. Brick and tile. 6. Terra cotta and faience. 7. Abrasives.

The formal reading of papers disclosed a large and varied list, some 52 papers being titled for delivery. Most of these were of a high order, both in the selection of topic and in the method of treatment; and it is worthy of note that nearly all of these showed that the contributors were well equipped with the latest theory and technique in their respective lines.

Among some of the more highly emphasized subjects were those of graphite, enamel, optical glass, and porcelain. The subject of graphite occupied most of the program of the first afternoon.

Symposium on Graphite and Bonding Clays

Mr. M. C. Booze of the U. S. Bureau of Mines at Columbus, Ohio, led in a series of seven papers from that fountain of ceramic activity. Mr. Booze showed the comparative properties of several bonding clays, in a curve which was made up of the summation and averaging of specific individual properties, such as strength, quenching action, resistance to oxidation, shrinkage, etc. The results are striking, though there seemed to be some doubt as to the reliability of the method of averaging, as compared with desirable practical results, but the paper was only part of the symposium offered by the able set of workers from the Columbus U. S. Bureau of Mines.

Interwoven with this set of papers was one by Professor G. H. Brown (and Mr. E. C. Hill) of Rutgers College, "Properties of Some Bonding Clays and Their Mixtures With Graphite." Professor Brown's paper was quite elaborate, being illustrated with several curves which showed the relations of the plasticity, refractories, vitrification, shrinkage, porosity, etc., at low and higher temperatures of treatment. No attempt will be made to reproduce this very scholarly article, but it may be said that Professor Brown determined the physical properties of a number of typical "bonding clays," for mixing with graphite, when burned under oxidizing and reducing conditions. In addition to typical crucible clays now in use, he also examined a few so-called "low-grade" clays which hitherto have not been regarded as suitable for crucible manufacture. As a result, Professor Brown concluded that the crucible manufacturers have been restricting themselves to an unnecessarily limited field. Some materials which have been hitherto rejected have given surprisingly good service in graphite crucibles of standard size and when used under commercial conditions.

Comparative Foundry Tests on Domestic and Foreign Graphites

As one paper followed another, most of them on graphite, it became evident that there was a sequence; and this became especially focused in interest in the paper of Dr. Reinhardt Thiessen, on "The Effect of the Shape of Graphite Flakes on the Structure and Durability of Crucibles," and that of Mr. R. T. Stull, on "Tests Under Brass Foundry Practice of Crucibles Containing Ceylon, Canadian and Alabama Graphite." In a word, both of these papers were aimed directly at the main question of comparing American with the best foreign graphite, which has been regarded, till recently, as that from Ceylon.

Dr. Thiessen is an expert with the miscroscope and the ultra-microscope; and those who had heard some of his earlier papers on related subjects, such as the structure of coal, were prepared to get at something definite, and were not disappointed. Dr. Thiessen showed that the prevailing structure of most American graphites was of rather large and rather rounded grains; and that most of these had such a distinct

lamination that the resulting mixture was sure to be laminated and to show the weakness of laminated cleaving. But the Ceylon graphite was shown to be made up, for the most part, of large and small grains, and with much irregularity of outline, but largely of angular shapes; and the cleavage was not of the always parallel lamination, but of much irregularity in dimension and direction, so that, when mixed in crucibles, the whole would develop a much more coherent mass than was possible with the average American graphite. Moreover, Dr. Thiessen showed that the chemical reaction of most graphites is "acid," which, with the "negative" reaction of most bonding clays, was sure to throw down a precipitate, which would only work disastrously in the desired bonding effect. So he induced "peptization" as a remedy, and with beneficial results; as shown by incidental reference to the ultramicroscopic examination of the well-burnt crucibles.

Mr. Stull's paper, on foundry practice of crucibles with Ceylon and American graphites, followed up this clear impression of some distinct progress in the mastery of the difficulties of finding a substitute for Ceylon graphite. This paper was all the more gratifying because it threw much light on the recent newspaper reports that the American manufacturer had been able to substitute for a considerable amount of Ceylon graphite the home product in the making of crucibles.

These tests were so conducted that they would well simulate the conditions of actual practice. The number of heats was noted, and this runs from ten to thirty or thirty-four, depending on the composition of the crucible, the conditions of manufacture and the kind of use the crucible might receive at the hands of the workman in the factory. Moreover, the crucibles were subjected to the action of two kinds of brass, one which melted easily and had a "mild" action on the crucible, and another that exerted a rough and heroic action on the crucible, both in the manner of melt and in the temperature of melt. Mr. Stull's paper was accompanied by several remarkable groups of curves, which showed many of the conditions of composition and treatment, running all the way from 100 per cent Ceylon and no American to no Ceylon and 100 per cent American graphite.

The best type of American graphite was found in the Alabama variety, but this Alabama graphite is mainly of a "flaky" texture and so, to change the flakes to grains, recourse was had to coking it in briquets, compressed under high pressure with tar as a binder. The anticipation was that the grains thus produced would act better than the original flakes of this Alabama graphite, but just the contrary was found to be the case. Incidentally, one of the seven papers from the Columbus workers was devoted to the effects of this variable pressure and tar content in briqueting the Alabama graphite.

Good Results From Alabama Graphite

In the main paper, by Mr. Stull, it was shown that, while some of the lowest and some of the highest number of heats possible for the crucibles were found for the straight Ceylon graphite, yet the careful tracing out of the curves of the mixtures of the Ceylon with the Alabama flake and the Alabama grain (coked) and with the "mild" and with the "hard" brass showed that some of the best maxima of possible heats were obtained with mixtures of the Alabama flake, and with increasing proportions of the latter. To be sure, these results are only tentative, and were advanced as showing the possibilities, but as such they are distinctly encouraging.

It must also be said that the conditions of working were arduous and exacting in the extreme. It takes nearly a month's waiting to manufacture a graphite crucible of the size used—about No. 60—and after that, when the crucible gets to the foundry, it ought to have three or four weeks more to dry out thoroughly; and doubtless many of the crucibles tested were not sufficiently aged and dried out to rightly undergo the best strains of practical efficiency. There were also many incidental points of interest; as the correspondence between wholly different curves, as the rising and falling at the percentage composition points of about 23 per cent, about 45 per cent and about 68 per cent of American (Alabama) flake—rising at 100 per cent in one case to over 28 heats per crucible. Moreover, the tests were conducted in sets of ten crucibles, and the correspondence of heats endured in the same set was very good.

Following the group of papers on graphite, there were the distinct sets of papers on enamels, on porcelain and on glass and optical glass.

Simple Chemical Tests for Enamels

In the enamel group should be noted the very practical paper by Mr. E. P. Poste of Elyria, Ohio, who described his search for some cheap, readily available and fairly constant acid which might be used by the large group of manufacturers who would not stop to employ expensive chemical tests but who needed some standard for the solvent effect of common solutions on enamel in its common uses. After a careful comparison of such acids as acetic, hydrochloric, nitric and sulphuric, he found in citric and tartaric acids almost the desirable objects of his quest. These acids are solid substances, they can be bought at every drug store, and they are fairly stable and permanent in storage. Thus it is perhaps possible to recommend a simple formula for the use of those interested, by means of which the solvent action of culinary solutions on enameled ware can be easily studied on a common standard. Moreover, citric and tartaric acids represent the common fruit solutions of domestic use to which enameled ware is commonly subjected. The tests were not quite complete with the paper, but the indications are that tartaric acid is perhaps the more desirable, as it can be easily obtained, and a standard solution can be made up, by weight, and with the simple addition of water.

Mr. Poste also described a search for clays by which to control the fusion temperature of enamel, illustrated by a curve of relative differences of increased temperatures of fusion.

Mr. P. D. Landrum of Cleveland described an attempt to make an enamel, using the clouding effects of titanium oxide (rutile) instead of the well-known tin-white substance. He found the presence of iron, which, strange to say, did not seem to control the color, though it may have interfered with it. But while he obtained the opaque effect, he invariably obtained also a yellow-

ish tint, which is not considered desirable in the trade. He noted the inference that the titanium, or some titanium compound, is precipitated in part in the enamel as "invisible" microscopic crystals.

Blistering of Enameled Steel Caused by Entrained Gases

One of the most interesting papers in the enamel field was by Mr. Chester Treischel and Mr. L. E. Barringer, of the General Electric Co. at Schenectady, on "The Cause and Control of Blistering in Sheet Steel Enameling." This paper was prefaced by the exhibition of some remarkable samples of "blistering," some of the specimens showing blisters of several inches in diameter. These were not between the enamel and the steel sheet, but were clearly in the steel body itself, causing the steel to split or laminate itself into still thinner layers. Mr. Treischel noted that metals are known to absorb and to transmit gases with great readiness, and the metals do not give off all of the absorbed gas on simple heating. Moreover, in the process of rolling thin sheet steel, it is a common matter for small bubbles of air to become entrained between the sheets, and these bubbles of air are often rolled out between the sheets, with the metal, attaining to a considerable area. These entrained gases, as hydrogen, or some of the entrained air, may cause serious difficulty. Tests were made to find the conditions of avoiding the absorption of hydrogen in "pickling," and it was found that by the use of a 3 per cent solution of acid the time was not seriously increased, and with careful rubbing off of the scale, before washing, better results were obtained.

Of course, many of the subjects must of necessity overlap; and this was well illustrated by papers on "The Manufacture of Glass Pots" and "The Casting of Porcelain Pots," which naturally were grouped together. As the program approached the manufacture of optical glass, interest was quickened by papers that brought out the nature of the elaborate and refined methods used.

Mr. W. S. Williams and Mr. C. C. Rand gave a paper in which this careful, methodical system was magnificently shown. The successive operations of drying the pots, burning the pots, melting the charges, stirring the melt, cooling the melt, and annealing the melt—each and all of these were shown to be carried on with the most refined control both of temperature and time; so that at any stage of the process the treatment of the pot or of its contents was guarded and foreordained with the utmost nicety and exactness, both in temperature and in time allowed. One interesting detail was a curve of the "stirring circles" followed. Another nice contrivance was the diagram of a "stirring-rod thimble," the use of which was obvious but which shows the nice attention given to the avoiding of contamination in the stirring of optical glass which seems to be an indispensable part of the process to secure uniformity of mixture and the removal of bubbles.

Gases Dissolved in Optical Glass

But perhaps the most startling and suggestive paper on optical glass was one by Professor E. W. Washburn of Urbana, Ill., entitled "Gases Dissolved in Optical Glass." He illustrated the subject by referring to the escape of carbonic acid from common "soda water." With this test as a cue, he described the attack on optical glass. The fundamental experiment was one in which a sample of good glass was melted in an inclosed steel box; then the interior of the box was connected with a vacuum, on which the whole pot of melted glass, finding escape for its contained gas possible from the reduced pressure, foamed up over the top of the pot, and this foamy glass when cooled resembled a light, spongy mass, as one can imagine who did not see the sample passed around. Professor Washburn then described in detail how he followed up the isolation of such occluded gases, and the analysis thereof, certainly determining eight-hundredths of one per cent of oxygen, by weight, and three-hundredths of one per cent of carbonic acid, a total of eleven-hundredths of one per cent by weight of dissolved gases. The mere momentary inspection of Professor Washburn's samples is enough to suggest the nature and complexity of the new problems involved in the production of perfect optical glass.

This was followed by a paper on "The Defects and the Testing of Optical Glass," by Mr. A. R. Payne of the U. S. Bureau of Standards at Pittsburgh. This remarkable paper, which without the accompanying slides is only "'Hamlet' with Hamlet left out," gave a clear catalog of the "seeds, striæ, stones and strains" found in optical glass and which must be avoided. In detail, it may be noted that Mr. Payne noted the "sheet," the "band," the "comet," the "hair" and the "surface" striæ, with some directions as to their causes. It is to be hoped that most of these illustrations may be preserved and published.

Practical Manufacture of Optical Glass

Of course, much of the program was characterized by refined theory and practice, but the charge of undue theoretical treatment of subject was well offset by such a paper in the optical glass list as that by Mr. George W. Morey of the Spencer Lens Co. of Buffalo, who gave the society a most admirable digest of his own actual and practical experience in making optical glass for the U. S. Government. He described in detail, briefly and to the point each of the stages of his method and treatment. One of the charms of this paper was the original and commonsense way in which Mr. Morey analyzed the conditions of initial and partial melting of the charge, with the inevitable results that those conditions must have on the rest of the charge and on the subsequent treatment. Thus, if the charge melts first at the top, then the part melted first flows down through the rest of the unmelted charge, leaving the top of the charge deficient in fluxing power. Moreover, this top part of the charge is the part through which the later escape of the gases given off must take place. Follow up this simple mental picture, and Mr. Morey's method of cutting out the hand stirring and introducing the mechanical stirring at each of the introductions of the parts of the full charge, and it is easy to see why he attained a complete cycle of treatment in a regular run of two days, and with most excellent results.

The subject of porcelain received much attention in quite a number of interesting papers, both from the theoretical and the practical standpoint.

It seems to be the gradually growing consensus among the experts who have given the matter careful consideration that the body of well-baked porcelain, and that having the most perfection of strength, translucency and resistance to solvent chemicals, is characterized by the generous production of a matte of interwoven crystals of sillimanite. Now, sillimanite is a well-known mineral, which occurs in certain gneisses, granites and similar rocks; the chemical composition of sillimanite is given as Al_2SiO_5; and the mineral is connected with its petrographic brethren, andalusite and kyanite, in that they all have the same empirical composition. The study of thin sections of porcelain mixtures shows that sillimanite is gradually produced as the quartz is absorbed by the matrix of the melt, and the approximation to the perfect porcelain composition and texture is paralleled by the attendant growth of the needles of sillimanite. All this was repeatedly shown by such good papers as that by Mr. A. B. Peck of the U. S. Bureau of Standards at Pittsburgh and of Mr. A. S. Watts of Columbus, Ohio; and some of the same methods of examination were employed by Messrs. J. W. Wright and S. I. Sewell of the U. S. Bureau of Standards at Pittsburgh, in their paper on "Some Physical Properties of Commercial Porcelain Bodies."

A typical mixture for making porcelain may be taken as 15 to 20 per cent of quartz, 30 per cent of feldspar, and the balance of ball clay and china clay in about equal proportions, say 25 per cent of each. Now, Mr. F. H. Riddle, in his paper, "Further Studies in Porcelain," showed that the development of the desirable structure and properties of good porcelain seemed to be largely dependent on the length of time used in grinding, not half an hour to an hour, as is the usual custom in commercial practice, but two or three hours. Further, Mr. Riddle showed that this extra grinding seemed to produce better results than quenching, and the extra time given to grinding seemed to be more important than the percentage of feldspar added to the original mixture. He also noted the remarkable influence of small quantities of oxides of calcium and magnesium in shortening the time of "maturing" the melt, and at a somewhat lower temperature.

The special question of casting pots for melting porcelain mixtures was considered in a well-illustrated paper by Messrs. J. W. Wright and D. H. Fuller of the U. S. Bureau of Standards at Pittsburgh.

The incidental use of the holder or jar for ball-mills was considered by Mr. C. W. Parmelee of Urbana, Ill., in a most interesting paper on "Porcelain Bodies for Ball-Mills," in which he examined in detail the various mills and machines for getting at the main idea of what is done and what is meant by the work and effect of "impact" and "rattler" in the tests. Comparative results were given for the action on quartz, clay and feldspar and the subject will be pushed to ascertain the best material for the ball-mill container.

Defects in Pyrometer Protection Tubes

One interesting phase of the actual necessities of present practice and of not finding material that ought to be at hand, but is not, was brought out in the paper by Mr. F. A. Harvey, of the Semet-Solvay Co. at Syracuse, N. Y., on "Porcelain Pyrometer Protection Tubes." This paper disclosed a most distressing state of things. Mr. Harvey is manager of a practical commercial laboratory, and while there are optical pyrometers that can give the thermal conditions for almost any temperature, yet it is indispensable for his work that he should have a graphic record to trace the stages of work. He had a pyrometer protection tube of some unknown make of fireclay that worked beautifully, but on its accidental breaking from the carelessness of a workman, he was unable to find a satisfactory substitute. Among all the attempts he made he found nothing completely satisfactory for the high temperatures involved—some 1450 to 1500 deg. C.—but the most approximate material was found in a "S. C. P." tube from Japan. The suggestion was made in the discussion that there are or ought to be registering optical pyrometers that would serve the purpose; but that does not seem to be quite worked out for the conditions required in Mr. Harvey's work. The paper is only another evidence of the quick response of American technique to the live needs of the times.

Cause of Dielectric Failure of Porcelains

Probably one of the most dramatic features of the porcelain papers was brought out in those bearing on the existence of quartz in porcelain, and its undesirability. This question was brought out, without evasion or camouflage, by Mr. A. S. Watts of Columbus, Ohio, in his paper, "An American Porcelain Containing No Free Quartz," and further sharpened by the "Suggested Discussion" on "A Possible Cause for the Dielectric Failure of Porcelains Which Are Apparently Free From Mechanical Defects," by Mr. Chester Treischel of the General Electric Co., supported by Mr. L. E. Barringer of the same company. In a word, the theory was put forward by Mr. Treischel that quartz is affected by the high potential strains of the alternating current. It is well known that when quartz crystals are subjected to high potential charges, at opposite axial points, they also become subject to distortion in dimensions and figure, and these may result in strain and fracture. This is the well-known "piezo-electric" phenomenon (pressure, electric strain). This may explain the failure of porcelains otherwise well fitted to endure the high potentials of insulators. Mr. Treischel, with most naive witticism, frankly confessed the danger of speculation, as he enumerated the three uses of a theory:

1. To explain facts as they are.
2. To develop further facts.
3. To give intellectual satisfaction.

Mr. Barringer read several letters from various noted specialists, giving more or less admission to the new theory, but he was frankly looking for light; and when such men, from such companies, frankly avow their sense of need for further light, it betokens some possibility of unlooked-for progress. Mr. Barringer noted that there are a dozen oxides that might be used as substitutes for quartz in porcelain, but this may be regarded as only the beginning of a new and marvelous chapter on the composition and manufacture of high-grade insulating porcelain.

In addition to the formal program, there was the usual banquet, presided over by Professor C. F. Binur.

ANNUAL BANQUET AT ASTOR, FEB. 4, 1919

Seated at the speakers' table are (from right to left): E. R. Behrend, J. Newell Stephenson, Dr. Charles P. Steinmetz, Thomas J. Keenan, Secretary T. A. P. P. I.; George W. Sisson, President A. P. P. A.; Justus A. B. Cowles, G. H. Mead, H. P. Carruth, President T. A. P. P. I.; Judge Charles F. Moore, Toastmaster; Robert W. Wolf, Henry E. Fletcher, Stuart D. Lansing, Dr. H. P. Baker, W. F. Robertson, Raymond S. Hatch.

Paper Associations Hold Joint Convention

Annual Meeting of the American Paper and Pulp Association and the Technical Association of the Pulp and Paper Industry—Economic and Technical Questions Discussed—Vocational Education Campaign in the Pulp and Paper Industry to Be Prosecuted

THE Technical Association of the Pulp and Paper Industry held its fourth annual convention in New York Feb. 3 to 6, conjointly with that of the American Paper and Pulp Association, in which body it was elected an organization member. It was decided that the scope of the A. P. P. A. should be extended to include the paper product manufacturers such as fine stationery, writing tablets, fiber containers, envelopes, merchandise bags, wall paper, etc., in addition to the present member organizations, who are strictly engaged in the manufacture of primary products such as binder board, cardboard, cover paper, glazed and fancy paper, gummed paper, tissue paper, vegetable parchment, waxed paper, wrapping paper and pulp.

The TAPPI program of forty addresses and committee reports was very inviting and brought forth about two hundred members from all parts of the lands of the eagle and maple leaf. Dr. C. P. Steinmetz of the General Electric Co. was the guest of distinction and proved his versatility by delivering an address on "The Principles of Waste and By-products." The keynote of his address was that chemistry is the greatest of the sciences, that the coal-tar industry is an example of man learning to control and utilize all the products given to him by nature and that the pulp and paper industry should make every endeavor to find uses for its marvelous wastes and turn them into by-products.

As the addresses, discussions and reports will be printed in full in the current issue of *Paper*, no attempt will be made to review the meeting in sequence but brief notes will be made to witness that the paper industry gave evidence of broad industrial scientific activity. In connection with Chairman Martin L. Griffin's report on the black ash furnace alkali stack losses, the Cottrell electric precipitation process was thoroughly discussed. The Brown Company has taken the initiative and installed the process in its Canadian sulphate plant, where it will receive capable development and perhaps lead to broad application in the alkali pulp industry. Mr. J. A. DeCew described his flotation process as entirely successful in recovering the pulp and china clay from the waste liquor from the Fourdrinier screens by simple air foaming and floating off the concentrated solids with a yield as high as 80 per cent. Not much good news was forthcoming about sulphite liquor, a small amount of highly refined concentrate being reported as in use as leather filler, and the raw concentrate as core compound and road binder, but the exhaust lines to the river still are carrying their polluting charge in undiminished volume.

The Morterud Process

The Morterud forced circulation external heater process of cooking pulp was described by O. L. Berger. The advantages to be gained by the successful operation of this process are revolutionary, but it is found that in American installation to date troubles have been experienced in getting tubes for the heater that will stand up against the corrosion of the circulating liquor. The process is reported by Mr. Berger to be working very successfully in Norway and full knowledge of the materials of construction used there are expected to make equally successful operation possible here. As the war has made it difficult to set stringent specifications and get delivery, it is hoped that the enterprising manufacturers who have taken chances and invested in this

new type of equipment will be able to obtain satisfactory tubes. If the Morterud process proves to be materially practical, much less digester liquor will have to be used and real progress will be made in reducing the volume of this waste to economical concentration.

"Common Sources of Error in Sulphite Liquor Testing," by W. E. Byron Baker, was a thorough discussion of analytical work, but would have served to better purpose if printed copies had previously been sent to the mill chemists so that time for real consideration of the author's new method could have been available and discussion held at the meeting. Great interest was not excited, as all but a few members adjourned to the halls.

Selecting Suitable Employees

The popular talk on vocational analysis for selecting suitable employees, by Dr. Katharine M. H. Blackford, was keenly listened to and made so favorable an impression that the time was extended another hour to allow the little wizardess to tell all about the vocations that the outer appearances of Messrs. Wolf and Fletcher indicated, and true to her reputation as an employment manager, she filled them out a card for the very jobs at which they are recognized by all the members of the association as eminently successful.

Dr. T. Poole Maynard spoke concerning the American clays and requested that the paper manufacturers cooperate with the kaolin producers in adapting our great domestic resources to this field. Dr. Maynard believes that some of the infinite variety of the American china clays are suitable and that the greater the co-operation the sooner will the problem be solved. Points brought up were that the pulverized and air floated clay contained much abrasive grit which cut the wire cloths seriously. Alkaline earths were also mentioned as undesirables, forming mineral soaps with the resins and perhaps giving rise to the so-called "tiny sheet." As most secondary clays were deposited in the presence of marine life, small amounts of lime are usually present, even when the reef formations are not found in immediate connection. No doubt the ground water of the entire territory below the crystalline line contains lime salts. However, there are some primary clays in Northern Georgia and Alabama which have been passed up by the investigators that are free from even traces of alkaline earth bases and with proper aging and preparation will resemble the imported material more closely.

Several of the groundwood mills are reported as having trouble with rusting pulp. One plant recently burned five hundred tons for fuel. When the rusts are examined under the microscope, a small black worm is found. Mr. John Stadler reported that his plant had had a touch of it several years ago and that it had been found that if the pulp was sterilized with chlorine, no rust worms would develop during storage.

Vocational Education Fostered

The greatest activity of the association is probably its endeavor to foster vocational education in the pulp and paper industry. It is now about to get a treatise out by contributions of a large staff of specialists on the following: Wood preparation, sawing into blocks, conveyors, piling, measuring, barking, drum and knife barkers, hand cleaning, splitting, chipping, screening, rechipping, drying, conveying to drip bins, hazards, mechanical pulp, kinds of woods, conveying blocks, types of grinders, Hall process, operation of grinders, dilution of pulp, losses, power, hazards; treatment of pulp, sulphite pulp, soda pulp, sulphate pulp, bleaching pulp, analysis and testing of pulp and raw materials, analysis of allied paper materials, preparation of rag and other fibers, esparto, waste papers, beating and mixing, loading, sizing, coloring, paper making, the paper machine, tub sized papers, finishing operations, special Fourdrinier machines, cylinder machine, special papers and boards, paper testing, trade customs, general mill equipment, laboratory equipment, glossary of terms. The association expects to spend $30,000 in preparing the manuscript, which will be turned over to a publishing concern for printing. This is the first time any large industry has followed such a program and no doubt the benefits to be derived will be as great as anticipated. Several other branches of industry will do well to follow this excellent example.

New Work in Wood Chemicals

Researches by the chemists of the Forest Products Laboratory at Madison, Wisconsin, upon the production of ethyl or grain alcohol from wood waste which before the war made possible a materially increased output were continued as a means of conserving foodstuffs and of relieving tonnage for overseas transport. Similar researches to produce the same product from waste sulphite liquor in pulp making have shown and demonstrated commercially that the yield of ethyl alcohol from this source can be increased more than 50 per cent.

Field studies were made and aid was given during the war to several large hardwood distillation plants upon the matter of temperature control as a means of increasing output. By use of proper method the increased output amounts to 3 gal. of 82 per cent spirit per cord and the acetate of lime product was increased as much as 5 lb. per cord of wood distilled. In addition to this, large quantities of fuel were conserved, due to the more efficient temperature regulations. This work supplemented much more extensive efforts conducted before the war.

Extensive researches were carried out upon the preparation of acetic acid by the fusion of sawdust with sodium hydroxide. It was shown that 15 to 20 per cent of the dry weight of the wood can thus be converted into acetic acid. This work is at present awaiting commercial or large-scale application.

Novel Use for Carbon Dioxide

Carbon dioxide has been successfully used in Australia for exterminating the weevil which has been destroying stored wheat in vast quantities. The infected wheat is stored in air tight stackhouses into which carbon dioxide is pumped until the live weevils are destroyed. The eggs and grubs which remain are killed by heating the wheat in special machines to 140 deg. F. for three minutes. It is claimed that the character of the wheat is unaffected and that there is no tendency for weevils to develop again unless exposed to a fresh source of infection.

American Sulphur Industry Expanding

Brief Account of the Sulphur-Bearing Saline Domes of the Gulf Coast—Operations at Matagorda, Enormous Boiler Equipment, Water Superheaters and Pumps—Fuel Cost of Primary Importance Because of Low Heating Efficiency

DUE to the patents granted to the late Herman Frasch during the period from 1891 to 1903, the sulphur industry has grown up in the United States under a patent monopoly. The development of the Louisiana deposit has long been recognized as a noted achievement, though it was as recently as 1912, when the Perkin Medal[1] was awarded to Mr. Frasch, that scientific literature began to bear any appreciable American sulphur content. How extensive the formations and what the origin of these great subterranean masses of sulphur were has never ceased to excite the keenest attention. Those who have studied the formations of the southern sections of the Gulf States, Georgia and all of Florida do not require elaborate geological theory to understand that this area is entirely of sedimentary origin, with the northern outcrops of the inclined strata indicating a thickness at the present coast of about 12,000 ft. This two-mile depth of fill may be said to consist entirely of the decomposition products of the original continental rock formation interspersed with marine animal remains. During the varying life and climatic periods, many individual strata were formed. It is of interest to note that great dislocations have taken place in these strata, especially near the present coast line, with resulting vertical seams offering free channels for the upward and downward passage of ground water. Whether the tidal forces due to the shifting waters of the Gulf or strains set up by temperature changes, etc., brought about these faults is open to conjecture. That similar eruptions are taking place in this locality during the present period is evidenced by such catastrophes as the Galveston tidal wave in 1900. The gulf being shallow, major subterranean eruptions in its floor are followed by high seas.

[1] Metallurgical and Chemical Engineering, Vol. X, pp. 73-82.

At certain points along these faults the so-called dome phenomena take place. As is well known, rock salt and large bodies of either petroleum or sulphur occur in them, the origin of which may be due to the brine being concentrated to saturation in the hot zone at the base of the fault, the destructive distillation of the marine fossils and the reduction of the sulphates by the hydrocarbon in some instances with the ultimate result that great quantities of sulphur are produced and the available petroleum consumed. There are many of these sulphur deposits in the Gulf Coast region, but commercial mines are at present confined to three localities only. The Union and Freeport Company properties have been long in operation, while the third, located near the mouth of the Colorado River at Matagorda, Texas, is now 90 per cent equipped for operation and will be known as the Texas Gulf Sulphur Co.

The surface indications of the domes are low mounds rising a few feet only above the flat alluvial plain which constitutes the Gulf Coast section. In the case of the Matagorda dome, the elevation above the plain is only some 15 feet with a diameter of approximately 3500 feet. The elevation is so slight that it cannot be distinguished in a photograph, the steepest grade being under 2 per cent. On the surface, the dome consists of alluvial material with no rock outcrop of any kind. Wells were originally located on these domes because of their elevation and small liability to be flooded during storms.

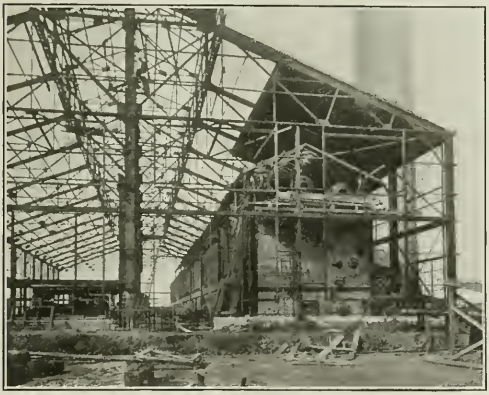
After the discovery of oil at Spindle Top near Beaumont, Texas, many domes were explored for oil, among others that at Matagorda. The mound produced some oil, but the total output was small and it was soon abandoned as an oil field. In the course of drilling for oil, sulphur was identified in the cuttings from several wells. At the time, however, little importance was attached to

the presence of sulphur. At a later date, the existence of important quantities of sulphur was proved, but the dome was not thoroughly explored until the Texas Gulf Sulphur Co. started drilling in the summer of 1917. Extensive drilling has confirmed the early records, and the deposit ranks today as one of the largest and most accessible sulphur reserves in the world.

The company was disposed to postpone the erection of a boiler plant until the end of the war, but the increasing demands of the Government for sulphuric acid and the possibility of a shortage of sulphur-bearing materials made it advisable to begin construction immediately. With the encouragement and priority grants of the Government, the company has erected during the war a modern boiler plant with all accessories and equipment needed for economical operation. The company will probably start production within sixty days at a rate of not less than 1000 tons daily. The reserves of high-grade ore, stated to contain at least several million tons of sulphur, are adequate for many years' production.

Matagorda Dome

The conditions found by drilling show a very flat-topped (practically horizontal) salt dome occurring at a depth of about 1000 ft. below the surface. The salt has not been drilled through, but is presumed to be of great thickness. Overlying this conformably is a stratum of salt and gypsum, while above this is the sulphur. The strata containing the sulphur show alternating layers of calcite and some gypsum. The sulphur horizon has been stated to be in the form of a half-dome, so that while the strata of gypsum and calcite are continuous,



BOILERS, PUMPS, ETC., USED IN HEATING ABOUT FOUR MILLION GALLONS OF WATER TO 325 DEG. F. WITH WHICH THE SULPHUR IS MELTED

a portion of these strata on one side of the dome contain little or no sulphur.

Above the sulphur horizon is a series of sediments consisting mainly of gumbo, shales (with shell), clays and sands. Embedded in the unconsolidated sediments are masses of limestone.

On the sides of the dome, where the dip is steep, drilling shows that the unconsolidated sediments extend to much greater depth, the underlying rock strata not having been reached. There is, then, not a mere flexing of the strata, but a distinct rupture involving immense forces over a comparatively small area. Subsequent erosion of the surface has left only small mounds to indicate the great displacement under the surface. In the nature of the case no correlation of upper strata is possible between various drill holes, nor is the sulphur horizon overlaid by the same formation in all cases. In general, of course, the limestone beds are found to be thicker and more numerous as greater depth is attained. In the case of Matagorda it might be more correct to refer to the dome as a plug practically flat on top with nearly vertical sides.

The manner of occurrence of sulphur in the mounds of the coastal plain region makes prospecting hazardous and expensive. There is no surface evidence except that furnished by the topography, and many of the mounds have been proved to be barren of both oil and sulphur. The physical character of the sulphur horizon has an important bearing upon the success with which the superheated water process may be applied. The formation must be sufficiently open to permit the hot water to circulate rapidly. Its depth and the overlying strata must be such that hydraulic and steam pressures can be maintained. The formation should be free from large subterranean water channels or passages through which the hot water might escape without obtaining sufficient contact with the sulphur. It is stated that the Matagorda deposit fulfills all these conditions to a desirable degree.

Main Features to Be Considered

From a practical standpoint, the main features to be considered in sulphur operations are transportation, fuel and water. As the product mined is cheap, it is apparent that a low transportation cost to the main sources of consumption is required to maintain economical prices. The Matagorda deposit is located on the Santa Fe Railway and being only two miles from Matagorda Bay and seventy-five miles from Galveston, will enjoy cheap ocean freights to the Atlantic seaboard as well as to foreign markets.

Fuel oil is obtainable at low cost either from the Texas oil fields or from Mexico in tank steamers. The company will require a minimum of 2000 barrels of oil daily.

The fuel efficiency of the process adopted in mining the sulphur is very low, generally under 3 per cent, comparing the heat units in the fuel with the heat necessary to melt the sulphur. A great deal depends on underground conditions. In some cases, large water courses are present which dissipate the hot water and reduce the efficiency. None of these openings have been found at Matagorda, however, so a high heat efficiency is expected. The main cost of producing sulphur is in the enormous fuel consumption, and the commercial success of the Frasch process was due to the low cost of fuel oil. It is estimated that from three and one-half to four and one-half million gallons of fresh water will be required daily, and in order to obtain this large supply shallow wells have been sunk and arrangements completed to utilize Colorado River water.

The pumping station occupies a space about 280 ft. long by 100 ft. wide. The equipment consists of fourteen 702-hp. Stirling boilers, oil fired, equipped with soot blowers and designed for 200-lb. steam pressure;

two 500-kw. General Electric steam turbo-generators, non-condensing, 2300 volt, 60 cycle, 3-phase; four Laidlaw steam-driven air compressors, each with displacement capacity of 475 cu.ft. per minute at 500 lb. operating pressure; three Webster feed water heaters, each with capacity to heat 3350 gal. per minute from 90 to 160 deg.; three Epping Carpenter boiler feed pumps 16 x 9 x 18 in. The hydraulic equipment is as follows: One 14-in. Duplex Worthington steam service pump (used as spare); three 6-in. Allis-Chalmers centrifugal service pumps; eighteen 10 x 6 x 16 high pressure mine water pumps; seventeen 12 x 7 x 16 low pressure mine water pumps, both Epping Carpenter manufacture; eight mine water heaters designed to use live steam direct for heating. The normal operation of the water system is as follows:

The service pumps deliver to the feed water heater, thence to the feed pumps and also the low pressure mine pumps, thence through the mine water heater to the high pressure mine pumps, and thence to the sulphur wells. By-passes are arranged so as to make the piping system flexible. Two radial brick stacks 200 ft. high by 13 ft. in diameter built by the M. W. Kellogg Co. complete the power house equipment. A water reservoir of 240 million gallon capacity assures tiding over the Texas drought. A system of shallow wells has been bored as an additional source, should the Colorado River stay dry for any unusually long period.

Oil is received from tank cars, pumped to two steel storage tanks 114 ft. 6 in. in diameter by 30 ft. high. From there it is pumped to two underground concrete storage tanks, each having 1200 bbl. storage capacity, whence three 7½ x 5 x 10 steam pumps deliver the oil direct to the boilers. These tanks and pump house are located about 140 ft. from the pumping station. Two oil heaters for warming oil up to the necessary temperature before combustion are located in the pumping station. All oil tanks and outside oil pipes are provided with steam pipes or coils in order to keep the oil sufficiently warm to flow in cold weather.

Machine Shop and Warehouse

The machine shop is approximately 116 x 75 ft.; the warehouse 170 x 60 ft. The machine shop has one 19-in., one 16-in. and one 12-in. lathes, one 25-in. shaper, one 12-in. pipe threader, one 6-in. and one 2-in. pipe machines; one 26-in. drill, one 20-in. drill and one 14-in. sensitive high speed drill; one woodworker including planer and saw. Each principal machine is driven by individual direct connected motor. One corner of the machine shop is partitioned off for a blacksmith shop and contains a 1600-lb. steam hammer, forge, anvil and tool grinder.

Industrial Gas Masks

The Bureau of Mines announces that it is making a preliminary investigation of gas masks with a view to establishing a list of approved devices for use in the mining and allied industries. After the preliminary investigation the Bureau will issue a schedule of tests which apparatus must meet in order to gain the approval of the Bureau of Mines. These investigations will be conducted at the Bureau's Pittsburgh Station by men who have had intimate connection with the development of mine-rescue apparatus and gas masks.

Gold and Silver Produced in the United States in 1918

The Bureau of the Mint and the Geological Survey have issued the following joint preliminary estimate of the production of gold and silver in the United States during the calendar year 1918:

	Gold		Silver	
State or Territory	Fine Oz	Value	Fine Oz.	Value[1]
Alaska	440,622	$9,108,500	796,836	$796,836
Alabama	36	700	2	2
Arizona	278,647	5,760,200	6,771,490	6,771,490
California	832,389	17,207,000	1,555,417	1,555,417
Colorado	621,791	12,853,500	6,982,313	6,982,313
Georgia	169	3,500	41	41
Idaho	30,764	636,000	10,188,056	10,188,056
Illinois	0	0	8,939	8,939
Maryland	0	0	164	164
Michigan	0	0	491,939	491,939
Missouri	10	200	40,948	40,948
Montana	153,375	3,170,600	15,341,793	15,341,793
Nevada	322,276	6,662,000	10,113,405	10,113,405
New Mexico	30,871	638,200	763,758	763,758
North Carolina	38	800	9	9
Oregon	60,951	1,260,000	150,207	150,207
Philippine Islands	44,202	913,700	12,597	12,597
South Dakota	328,305	6,786,700	165,865	165,865
Tennessee	263	5,400	131,931	131,931
Texas	5	100	612,436	612,436
Utah	152,018	3,142,500	13,439,811	13,439,811
Vermont	47	800	5,117	5,117
Virginia	20	400	2,967	2,967
Washington	16,556	342,300	302,446	302,446
Wyoming	18	400	719	719
Total	3,313,373	$68,493,500	67,879,206	$67,879,206

[1] Valued at the Government buying price of $1 an ounce.

These figures, compared with those showing the production in 1917—gold, $83,750,700; silver, 71,740,352 ounces—indicate a reduction in the output of gold of $15,257,200 and in that of silver of 3,861,156 ounces. The output of gold in 1918 was the smallest in twenty years and that of silver was the smallest since 1913.

Ecuador Establishes Crude-Salt Monopoly

The Minister of the Treasury of Ecuador has just published the text of the law making effective the salt monopoly established there by the legislative decrees of Oct. 13, 1916, and Sept. 26, 1918, reports Consul General Goding. This law, after stating that sea salt will be handled exclusively by the Government and consequently will not be let out to the highest bidder, also that proprietors and owners of salt mines may sell only to the Government, fixes the price which the Government will pay and for which it will sell salt in the republic. The law also limits the amount of salt that will be sold to any one person.

Importation of foreign salt is prohibited, "except in case it should appear for any reason to be impossible to supply the republic with salt from the national mines. This proscription does not apply to refined salt, unless the Government should establish refineries for that purpose."

The Executive, however, is authorized to introduce the refining of salt into the republic, investing for this purpose such sums as may be necessary. The law provides that the Executive shall fix the price of the refined salt, taking into account the expenses incurred in refining it.

Resumption of Trade With Serbia and Rumania

By a recent ruling of the War Trade Board, all persons in the United States are authorized, subject to the rules and regulations of the War Trade Board and the import regulations of these countries, to trade and communicate with persons residing in Serbia and Rumania.

Aids to Foreign Trade in the Chemical Industry

MARKED activity has been displayed by the Bureau of Foreign and Domestic Commerce in its efforts to promote foreign trade. Through the appropriations made by Congress this branch of the Department of Commerce, under Secretary William C. Redfield's direction, has broadened out to all parts of the world and has sent trade commissioners, as they are known, to all countries to glean such information as will constitute reports that should be invaluable to American manufacturers along various lines that have been developed in this country, particularly during the war period.

Now that priorities have been raised and appropriations have been made by the operating division of the Shipping Board, particularly for South America, there will be a tendency toward improvement in the export trade.

Many manufacturers throughout this country have been perplexed as to the best method of securing export trade in their particular line. Herewith is published a chart that has been issued by the Bureau of Foreign and Domestic Commerce, dealing with foreign trade promotion, which, if closely studied, will show the information that is available from our own Government that should furnish a general knowledge of the subject, and serve as a guide to the prospective market. In conjunction with the information shown thereon, there is also published a list of the publications, which can be obtained by writing to any of the district offices or to Washington, specifying the line of information sought.

Recent appropriations have been granted to this department and the service will still be carried out; and through their medium, known as the *Commerce Reports*, issued daily, they are striving to keep the American public informed on the real conditions as they exist.

It is surprising to learn how little is generally known of the fact that this information has been available from the Government agencies, and it is with a view of furnishing this information and encouraging co-operation with this department of our Government that CHEMICAL & METALLURGICAL ENGINEERING is presenting this chart. This information is available to those interested in obtaining it.

British Import Restrictions

All restrictions limiting importation of sirup, molasses and like articles will be removed Feb. 24, 1919.

The following articles will again be on the list of prohibited imports after Mar. 1, 1919, and can then be imported only under special license:

Aluminium and manufactures of aluminium, including aluminium powder; cement, fatty acids, methyl alcohol, salt, soap, weighing machines, scales and balances of all descriptions.—W. T. B. R. 557.

Acetone

By H. P. Bassett, Ph.D.

FOR several years previous to the war the amount of the acetone made in this country was small, the larger part of our gray acetate of lime being exported to foreign countries, to be used in various industries, like synthetic indigo, acetic anhydride, acetone and other products of a lesser volume, as asperin and the like, in the drug trade.

Practically all of the gray acetate of lime produced in this country at that time was obtained from the distillation of wood, to produce charcoal for the charcoal iron industry, and was necessarily dependent on the sale of the charcoal to make the industry pay. For this reason, shortly before the outbreak of the war, many of these plants were shut down, but on the outbreak of the war both charcoal iron and gray acetate of lime came into great demand. Every one is familiar with the extreme test the English Government underwent in its search for acetone to use as the solvent in the manufacture of cordite. Several new plants were built and old ones enlarged to produce the acetone which had been demanded over night, as it were.

New sources of this material were developed, such as the fermentation of molasses to alcohol and the alcohol to acetic acid, the fermentation of kelp and the transformation of acetate into acetone and similar solvents.

The almost exclusive use of acetone during the war was in the manufacture of military explosives, especially for the English Government, and consequently any other use was practically prohibited.

In this search for acetone, one source of this material seems to have been overlooked, namely, that from wood, sugar, gums, etc., mentioned by Freny. (Ann. Chim. 59-7). Freny mentions a source of acetone from the distillation of the above products, especially wood, with eight parts of lime. This does not look attractive on account of the large amount of lime required, but several years ago I had occasion to investigate this problem and much less lime is needed, if the proper conditions are observed.

In order to obtain the best results the mixture of lime and sawdust or wood in a similar state should not be heated too rapidly, requiring about ten hours to reach the maximum heat, and again the vapors should be removed from the retort as quickly as possible after they are formed. This may either be done by steam or an inert gas, such as carbon dioxide, preferably steam. Under these conditions a good yield of acetone and higher ketones can be obtained with 2½ parts of lime to one part of dry wood.

Under the above conditions a yield of 26 per cent of acetone and mixed ketones can be obtained, and as the higher ketones are now in demand and in many respects for certain purposes it is desired to have a solvent of the nature of acetone and one that is not so extremely volatile, these higher ketones are preferable. For many purposes, like films for aëroplane dope, etc., where the evaporation of the solvent is wished to be retarded, the higher ketones find an extended use.

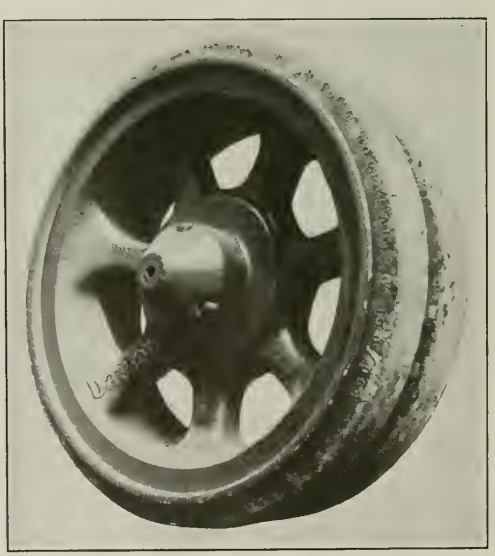
This, however, as a permanent industry has the same disadvantages as that recently mentioned in one of the late numbers of this journal[1] in an article by Tomlinson, entitled "Wood-Waste as a Source of Ethyl Alcohol."

It is entirely possible to use sulphite waste liquors in this same manner, as they can be easily evaporated to a thick or rather thick consistency and then by adding the lime will dry this liquor to the point where it can be dried on a chain drier, drum drier or, better still, in a rotary drier if knockers are provided to keep it knocked from the sides.

The uses for acetone and higher ketones have been greatly extended during the past four years and promise to afford many new outlets for such solvents as, for instance, in the waterproofing of cloth and artificial leathers.

Electric Steel Castings

WHEN the modern motor truck first made its appearance in the business world, it was in many ways still a rather crude affair. But constant improvements and changes have developed it, until to-day it is one of the most effective methods of commercial transportation. One of the latest of these improvements has been the invention of a one-piece steel wheel for motor trucks. The constantly increasing weight of loads and the high speed which have been demanded of the motor truck proved too great a strain on the old-style wheel of the built-up type. A loose spoke on a motor truck wheel was found to be a much more serious matter than



ONE-PIECE STEEL WHEEL FOR MOTOR TRUCKS

it was in the days of the horse and wagon. "Flats" which developed were very destructive of bearings and axles and, in fact, had a destructive effect on the entire structure of the truck.

Automotive enginers, who were quick to see this trouble, studied the matter carefully. It was universally accepted that a metal wheel was the proper type

[1] Chemical & Metallurgical Engineering, Vol. 10, No. 7, Oct. 1, 1918.

for motor truck use and would meet the great need of strength. As a result numerous styles and types of metal wheels were evolved in an effort to build a wheel which would answer every requirement of truck haulage. While these different types of metal wheels were each an improvement in certain ways over the old-style built-up wheel, they were lacking in two or more of the essential qualities.

The ultimate wheel, which answers every requirement and which is finding great favor among manufacturers of motor trucks and among truck owners, is the Dayton steel wheel. This is a one-piece wheel of electric furnace steel. It at once overcomes any possibility of loose spokes, because of its one-piece construction. Spokes and rim are hollow and of uniform thickness, which result in lightness of weight that is astonishing. As will be noted from the illustration herewith, it has also a peculiar construction in its odd number of spokes and sweeping curves. This design has the effect of dissipating excessive road shocks so that they do not reach the axle, but are distributed throughout the wheel, which greatly prolongs the life of the truck.

Recent Government tests have proved that the Dayton steel wheel has remarkable strength and resiliency. And the fact that Government experts were impressed with the advantages of this style of wheel is evidenced in the specification of steel wheels of this type in the construction of motor trucks for war work.

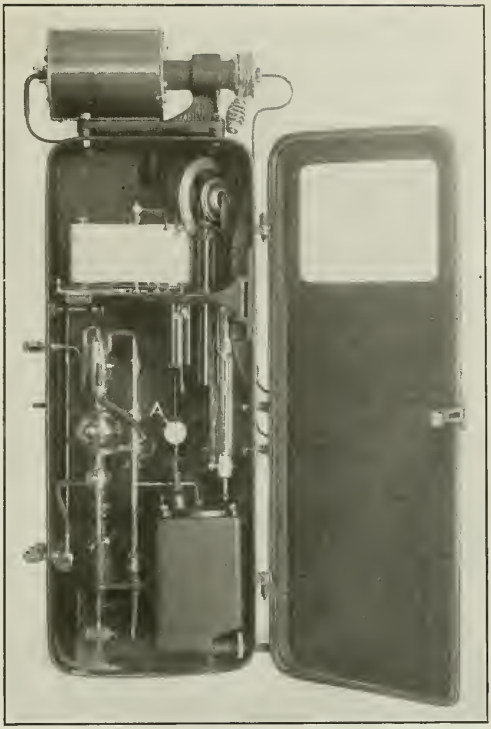
An extensive national advertising campaign which is now being conducted on this wheel is arousing a great deal of interest among manufacturers of motor trucks and among users. There is bound to be a wide use of the Dayton steel wheel for motor trucks.

Hydrogen Recorder

THE Harger hydrogen mono recorder is adapted for almost all industrial purposes, as a variety of ranges are provided. Similarly to the Mono CO_2 recorder, an auxiliary apparatus which also analyzes automatically carbon monoxide, methane, carbon dioxide and oxygen can be attached to this instrument.

Briefly the principle of the hydrogen mono is as follows: The gas is trapped off in a 100 cc. burette by means of a falling mercury column. The motive power of the instrument can be either water or compressed air. When the sample is thus trapped off, it passes into an electric oven in which there is inserted a cartridge which at high temperature oxidizes the hydrogen in the gas to water. This water vapor follows the gas sample, is condensed and removed. Thus contraction is brought about in the gas mixture and as at the same time the original volume is altered according to the amount of hydrogen absorbed, the change of this volume is recorded in the usual manner on a sixty days' chart of such width that each per cent and fraction thereof can be plainly read with accuracy. The electric oven requires about 200 watts and is made for a voltage of 110.

The oxidation cartridge is gradually reduced and arrangements are made for convenient replacement. The cartridge may also be regenerated by heating. Its durability depends upon the amount of carbon dioxide and methane in the gas analyzed. The smaller the amount of hydrogen the longer it will last, and on an average of 10 per cent of hydrogen and a speed of thirty analyses per hour the cartridge will retain its full strength for about two hundred hours. There is no other maintenance cost connected with the instrument and it should, therefore, be considered as a very important addition to the chemical plant equipment put out by the F. D. Harger Co. of Buffalo.



HYDROGEN MONO RECORDER

Ordnance Scrap Material for Sale

The War Department authorizes the following from the office of the director of sales:

The estimated value of ordnance scrap material on hand Dec. 31, 1918, by classes has been reported by the stores and scrap section of the Ordnance Department to the director of sales. The list is as follows:

	Pounds
Aluminium scrap, all kinds	46,608
Brass scrap, all kinds	5,842,351
Cupro-nickel scrap, all kinds	781,392
Copper scrap	691,580
Machine shop borings and turnings	9,714,139
Steel, heavy melting, scrap	20,771,061
Steel, low phosphorus, scrap	5,988,477
Nickel steel, heavy melting, scrap	5,518,359
Nickel steel, borings and turnings	15,654,919
Cast and malleable iron, scrap	13,692,718
High speed borings, turnings, scrap tools	63,365
Mixed and miscellaneous iron and steel scrap	5,195,748
Miscellaneous scrap, consisting of rags, waste paper, etc.	803,956
Lead dross scrap	153,005
Lead scrap	322,355
Brass ashes and sweepings	1,067,571
Burlap	256,963
Spent acid	1,495,250
Amatol	269,847
Ammonium picrate	5,000
Tetryl	18,660
Total	88,352,324

It should be noted, however, that scrap inventories vary every day.

Synopsis of Recent Chemical and Metallurgical Literature

Slagging Gas Producer.—A description of the slagging gas producer working on coke was recently republished in the *Iron and Coal Trades Review* from *Stahl und Eisen*. It is a short blast furnace, with a relatively deep hearth, 5 ft. 3 in. in diameter, a shallow bosh, and a vertical shaft, the whole being 16 ft. 5 in. high. Sufficient high-iron slag from a mixer or a basic open-hearth is charged with the coke to be gasified in order to properly slag its ash—30 tons of coke being charged in 24 hours. The blast is warmed in a heat interchanger to 70 deg. C., and blown through water-jacketed tuyeres at 15.7 in. water pressure. Slag is tapped at four-hour intervals, while 8 to 12 hours are required to accumulate 8 in. of iron in the bottom of the hearth. The iron produced contains 8 to 10 per cent of manganese and somewhat more phosphorus. The top of the producer is covered by a flat dome of refractory brick, pierced by numerous peep holes. In operation no poking or stirring is necessary, the gas leaves the shaft at about 700 deg. C., is practically free from tar, and has the following analysis:

CO_2	0.3 to 0.7
CO	33.0 to 33.5
CH_4	1.2 to 1.3
H_2	0.1
H_2O	12 g. per cu.m.
S	0.28

The coke contained 84 to 88 per cent carbon, with a calorific power of 7000 calories, while the yield of the above gas amounted to about 175,000 cu.ft. per British ton. This producer has been operating satisfactorily at the Georgesmarienhütte for over two years, working for thirteen months continuously before the lining of the hearth had to be removed.

The Elastic Indentation of Steel Balls Under Pressure.—C. A. Briggs, W. C. Chapin and H. G. Heil of the Bureau of Standards have studied the effect of pressure on the steel balls and rounded-end length standards used for munition gages. For the light pressures studied they conclude that the deformation of the ball-surface not actually in contact is very small. They therefore confined their attention to measuring the area of contact made by flat and spherical surfaces, one of which was of transparent glass. This area was the central spot in the system of Newton's rings formed in each case. From experimental and theoretical considerations, the following general formula was derived which gave very excellent results:

$$\Delta G = 0.518 P^{\frac{2}{3}} \left[\frac{G_1 + G_2}{G_1 G_2}\right]^{\frac{1}{3}} \left[\frac{1}{E'_1} + \frac{1}{E'_2}\right]^{\frac{2}{3}}$$

Here ΔG = the mutual indentation between the surfaces in contact; P = the pressure acting between the two surfaces; G_1 and G_2 = the radii of curvature of the two surfaces; E'_1 and E'_2 = the indentation moduli of the surfaces G_1 and G_2.

The indentation modulus is given by the expression

$$E' = \frac{E}{1 - u^2}$$

where E = Young's modulus; u = Poisson's ratio.

The case of the indentation of steel balls between flat steel surfaces appeared to have the most immediate importance. Consequently the following special formulæ were derived, using tabular values for the physical constants involved. For precision work it would of course be necessary to determine Young's modulus and Poisson's ratio for the materials in hand, as well as to check the

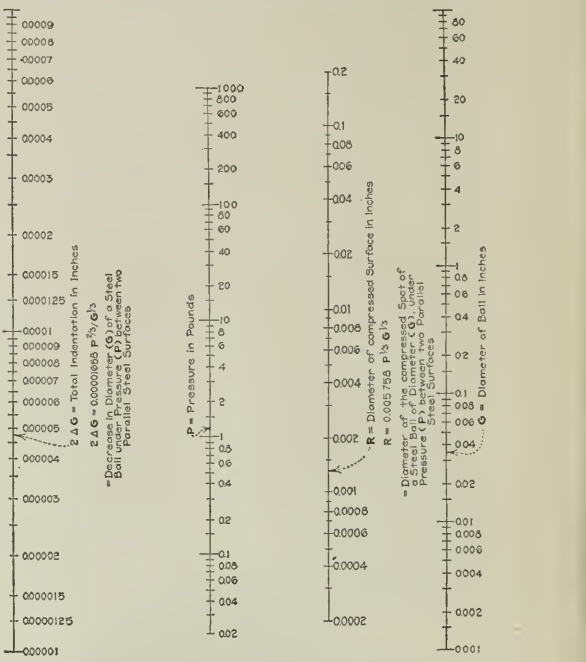


FIG. 1. INDENTATION OF STEEL BALLS

extrapolation of the general formula from the very low pressure used by the authors (20 pounds pressure on ⅜- and 1-in. balls) to the region in use.

Indentation for Steel Balls Between Flat Steel Surfaces:

$$2\Delta G = 0.0000166 \frac{P^{\frac{2}{3}}}{G^{\frac{1}{3}}}$$

where $2\Delta G$ is given in inches.

Diameter of Area of Contact Between the Surface, Steel Against Steel:

$$R = 0.00576\ P^{\frac{1}{3}}\ G^{\frac{1}{3}},$$

where R is given in inches.

Average Pressure Over the Area of Contact, for Steel Against Steel:

$$S = 38.400 \frac{P^{\frac{1}{3}}}{G^{\frac{2}{3}}}$$

where S is given in pounds per square inch.

Fig. 1 gives an alignment chart for graphical solution. A straight line drawn between any two points determines corresponding values on the intercepts with the other axes.

Divorce of Pearlite After Cold Working.—J. H. Whiteley read a paper before the May meeting of the Iron and Steel Institute (British) giving the results of a research started by the observation that the color-carbon given by a cold-worked sample is considerably higher than the determination on the same metal in

an unstrained condition. A piece of eutectoid steel showing very fine pearlitic laminations was cold-hammered from $\frac{1}{2}$-in. square to $\frac{1}{4}$-in. square. After annealing at 650 deg. C. for one hour it was found that almost the whole of the cementite had been divorced and now appeared in small spheroids. In a fresh piece the laminations showed a decided tendency to break up after annealing for 15 minutes at 500 deg. C., while 15 minutes at 600 deg. caused almost complete divorce. Considerable difference in speed of the transformation in various portions of the areas was noticed, however. In order to discover the relation of the degree of deformation to the speed of spheroidizing, a $\frac{1}{2}$-in. bar was struck lightly twice, reducing its cross-section to about $\frac{7}{16}$ in. Two hours' annealing at 680 deg. showed only traces of the original laminations. The authors suggest that this acceleration of divorce on annealing may prove to be a delicate test for small amounts of strain in pearlitic steel. Coarse pearlite in low carbon steels gave the same results as above. The spheroidal pearlite obtained after cold working and annealing cannot be distinguished from the "granular pearlite" of quenched and tempered steels; the two probably are identical in structure.

As is well known, to bring about this result in unstrained steel requires many days' heating. It is not thought that the cold working ruptures the cementite laminæ, thus presenting fragments which later ball up by surface tension. H. LeChatelier's suggestion that the bent laminations are in a state of elastic tension, which state of strain has been shown to increase the solubility of crystals, may have considerable bearing on determining the points where the cementite layers first part.

Again, cementite films are known to be in a metastable condition. Goerens has also shown that the strain in iron due to cold work is removed rapidly at the same temperature at which rapid divorce starts. It is very possible that the slight changes in volume, crystallization and surface tension accompanying relief of internal strain may disturb the metastability of the cementite laminæ, resulting in accelerated spheroidizing.

Finally, the author suggests that the false stability of the films of cementite is disturbed by working, and it breaks up much as does a thin cylindrical stream of water issuing from a tap when subjected to slight vibrations.

Heat-Treating Shells.—A paper was read before the Steel Treating Research Society at Detroit in March, 1918, by J. M. HALL, giving the methods of heat-treating shells used at the Hamilton Steel Wheel Co. of Hamilton, Canada. The chemical and physical requirements for the principal shells are:

	18-Lb. British Shrapnel $3\frac{1}{2}$-In. Blanks	Finished Shell	6-In. High Explosive
Carbon	0.48 to 0.60	.....	0.40 to 0.55
Manganese	0.5 to 1.0	.....	0.60 to 1.0
Silicon	Under 0.3	.....	0.15 to 0.35
Phosphorus	Under 0.06	.....	0.0 to 0.05
Sulphur	Under 0.05	.....	0.0 to 0.05
Elastic limit, lb.	42,600	80,700	More than 42,600
Ultimate, lb.	78,500	126,000	78,500 to 110,000
Elongation, per cent.	20 in 2 in.	8 in $\frac{1}{2}$ in.	14 to 30 in 2 in.

After finish-boring and rough-turning the rolled bars used for these shells they are ready for the quenching operation. Heating is effected in an oil-fired furnace with a combustion chamber underneath the hearth. The shells are ranged into the furnace on end, and slowly heated to from 1500 to 1700 deg. F. depending upon the carbon content. The hot shells are then quenched in a soluble oil. A very handy tank for this operation, especially in automatic furnaces, consists of a round bath, 7 ft. in diameter and 3 ft. deep. Inside this bath is a turntable containing a series of baskets into which the hot shells are dropped and remain upright, base downward. The turntable slowly rotates, and the quenched shell is withdrawn on the opposite side after immersion for about 6 minutes. The average oil temperature is kept below 200 deg. F. by circulation over cooling coils. After quenching, the shells are drawn in a similar furnace to a temperature of from 950 to 1350 deg. (depending upon the carbon content) and air cooled. The open end is immediately heated to 1100 deg. F. in a metal bath, "nozed," and immediately buried in flake mica for slow cooling.

High explosive shells are forged from open-hearth steel blanks. For instance, a 6-in. shell is made from a blank cast on end in a preheated cast iron mold with a hot top, $6\frac{7}{16}$ in. in diameter, tapering at the bottom. The metal is poured slowly through a 1-in. nozzle to minimize piping. The hot castings are stripped, 20 per cent of the top of the blank is cut partly through and then broken. This discards the piped top and gives a fracture for inspection. Forgings from properly cast blanks give as good results as those from rolled bars. The bars are heated for forging in a flat-hearth, oil-fired furnace, 7 ft. by 14 ft. in dimensions, with a capacity of 100 6-in. shells. It requires $2\frac{1}{2}$ hours to complete a furnace cycle, the steel being held at the correct heat (1800 to 2000 deg. F.) at least 15 minutes, since it is important that the interior of the bar attain the correct temperature and that the forging be done on a cooling piece of metal. Forging is done in various ways: The billet may first be pressed into the die—an operation called "bunting"—pierced large, and the whole then drawn through a succession of rings to reduce the size to the proper dimension. As an alternative method, the shell may be bunted and pierced to size, or finally a round billet may be pierced to size in one operation. The last method is now usual practice in Canadian shops and apparently gives as good results as the two others. After forging, the temperature is about 1700 deg. F., and the shell is cooled on a slow-moving conveyor leading through a draft tunnel. The time required to reach a temperature of 800 deg. F. is from one to two hours, depending upon the carbon content of the shell. About 2 per cent of the forgings are then selected for physical tests, and test bars are cut from the base end by an acetylene torch.

If the shells are rejected as having too high an ultimate strength they are annealed to 1600 deg. F. and allowed to cool in the furnace. This practice will reduce the ultimate of a 60-point steel 7000 pounds and increase the elongation 6 per cent. On the other hand, low carbon steels which are rejected for opposite causes are heated to 1550 deg. F., placed on rollers under three pipes blowing air at 12 oz. pressure upon them through a number of holes. The shells are cooled to 800 deg. F. in 7 minutes, while the ultimate strength is raised 8000 pounds with a corresponding reduction of the elongation of only 0.6 per cent. In this manner the final rejections at the plant in question have been reduced to less than 1 per cent.

Book Reviews

SCRAP METALS. By *George H. Manlove* and *Charles Vickers.* 278 pages; price $2.00. Cleveland, Ohio: The Penton Publishing Co.

The authors point out that although scrap occupies a place as one of the most important raw material departments of the iron and steel world, the scrap industry has had no literature. They state that the present effort to present a broad review of the business originated in a series of articles recently printed in the *Daily Iron Trade and Metal Market Report.*

The book is divided into two parts, the first of which, by Manlove, treats of steel and iron scrap, while the second, by Vickers, treats of non-ferrous scrap. In the first section of the book the author discusses the importance of the scrap industry and throws much light on the conventional classification of scrap, including specifications for scrap intended for various special purposes; methods of collection as practiced by the producers in industries in which scrap metals are by-products, and by scrap dealers, large and small, are described in outline; and an account is given of the methods of organization in current use as well as conditions governing price regulation. These features are sufficiently developed to make the book extremely useful to all persons who are either directly or indirectly interested in the purchase or sale of scrap.

In this country, until within recent years, waste has proceeded in many industries without hindrance. Since the war the widely advertised salvage operations on warfronts by the belligerent Powers have aroused new interest in the possibilities of such operations as applied to American industries. As a consequence there are now appearing in trade journals detailed descriptions of the procedure at present followed in certain plants. This book gives an interesting summary of some of the efforts which have been made in this country, especially by railroad companies. This account should make the book well worth reading for persons not especially interested in scrap because of the suggestions for the reclamation of waste which can often be carried over bodily to other industries. The author has succeeded in presenting his subject in such an interesting manner that reading for this purpose by such persons will not be difficult.

The second part of the book, which deals with non-ferrous scrap metals and alloys, is briefer, but, like the first part, contains much valuable information and suggestions concerning the reclamation and disposal of such materials.

Both of the authors are to be congratulated on producing a useful book on this important but hitherto neglected subject.

Personal

Mr. C. N. Barney has been appointed representative for the Worthington Pump & Machinery Corporation of Virginia at the New York office, 115 Broadway.

Prof. W. D. Bonner, professor of chemistry at the University of Utah, is also acting as consulting chemist to the U. S. Bureau of Mines and is in charge of laboratory investigation on oil shales.

Mr. Arthur F. Braid has been appointed sales manager of the metal and alloy department of the Metal & Thermit Corporation, New York City.

Mr. Frederick K. Brunton is now with the Phelps-Dodge Corporation's smeltery at Douglas, Ariz., having recently left Morenci, Ariz.

Mr. F. W. Bunyan is now chief chemist of the Noble Electric Steel Co., Heroult, Calif.

Dr. E. E. Charleton, assistant in chemistry at the University of Illinois, has resigned that position to accept one with the du Pont Powder Co. of Wilmington, Del. He will be succeeded by Lieut. J. B. Brown, who has recently been released from military duty at the Chemical Welfare Service, Washington, D. C.

Captain R. L. Kramer, C.W.S., who has been officer in charge of the men in uniform at the War Laboratory, Johns Hopkins University, Baltimore, Md., has been released from service and has entered as a graduate student in chemistry at Johns Hopkins.

Mr. C. E. Littell has resigned his position as chief chemist of the Providence Gas Co., to take charge of the heating of the new Koppers by-product coke and gas ovens. Before going to Providence, Mr. Littell was connected with the United Gas Improvement Co. of Philadelphia, Pa.

Mr. J. J. McKee has severed his connection with the C. A. Dunham Co., Marshalltown, Ia., to accept a position with the Machinery Utilities Co., 501 Fifth Ave., New York City.

Mr. H. C. Parmelee, editor of Chemical & Metallurgical Engineering, was elected an honorary member of the Teknik Club of Denver at a meeting held on Jan. 14. Mr. Parmelee was secretary of this society for some years, at which time he was Western Editor of this journal with an office in Denver.

Lieutenant Lloyd Van Doren, C.W.S., who was formerly in General Sibert's office in Washington, D. C., has accepted a position as Carnegie assistant under Mr. Frazer of the Johns Hopkins University, Baltimore, Md., and will work for the remainder of the year on osmotic pressure.

Captain Gerald L. Wendt, who was discharged from the Chemical Welfare Service on Dec. 1, has taken up his duties again as assistant professor of chemistry at the University of Chicago and as a member of the editorial board of the Bulletin of the Chicago Section of the American Chemical Society.

Mr. Harry J. Wolf of the Malm-Wolf Co. has been appointed consulting mining engineer in the U. S. Bureau of Mines.

Current Market Reports

The Non-Ferrous Metal Market

Saturday, Feb. 8. — Liberal price concessions have been made but no heavy buying has resulted.

Aluminium:—The Government prices on ingots 98 to 99 per cent Al are $660 a ton f.o.b. plant in 50-ton lots; $662 down to 15-ton-lots; and $666 down to 1-ton lots, which prices will continue until the first of March. Prices per pound for small lots vary from 40c. to 45c.; sheet aluminium, 18 ga. and heavier, 42c.; powdered aluminium, 100 mesh, 70c.

Antimony:—Antimony continues to sell at from 7⅞ to 7½c. per lb. with no changes in view.

Copper:—The situation in the copper market is extraordinary. Sales at 18¼c. have been made, but stocks are still accumulating.

Copper sheets, hot-rolled	lb.	$0 29	$0 33
Copper sheets, cold rolled	lb.	.30 —	.34
Copper bottoms	lb.	.37 —	.41
Copper rods	lb.	.25½	
Copper wire	lb.	.23	
High brass wire	lb.	.24½ —	.26½
High brass sheets	lb.	.24½ —	.26½
High brass rods	lb.	.23½ —	.25½
Low brass wire	lb.	.26½ —	.28½
Low brass sheets	lb.	.26½ —	.28½
Low brass rods	lb.	.27½ —	.29½
Brazed brass tubing	lb.	.35½ —	.37½
Brazed bronze tubing	lb.	.40½ —	.42½
Seamless copper tubing	lb.	.35 —	.37
Seamless bronze tubing	lb.	.40½ —	
Seamless brass tubing	lb.	.34 —	.36
Bronze (gold) powder	lb.	1.00 —	1.75

Lead:—This market is stagnant even at 5c. quotations, but the validation of informally made war contracts will soon reawaken activity.

Tin:—The U. S. Steel Products Co. has liquidated 3000 tons of the original 10,000-ton stock at the 72c. basis. It is expected that it will take several months to dispose of the remaining stock, after which prices will fall sharply.

Zinc:—Spelter has fallen with spot New York at $135 per ton and futures at $128. East St. Louis spot is quoted at $128.

OTHER METALS

Bismuth	lb.	$3 50 —	$3 65
Cadmium	lb.	1 50 —	
Cobalt	lb.	2.50 —	3.50
Magnesium	lb.	1 75 —	2 10
Mercury	75 lb.	95 00 —	
Mercury	lb.	1 95 —	
Nickel	lb.	40 —	45
Tungsten	lb.	Nominal	
Iridium	oz.	175 00 —	
Palladium	oz.	135 00 —	
Platinum	oz.	105 00 —	108.00
Silver	oz.	1 01½—	

The Iron and Steel Market

Any doubt that may have existed as to the character of the iron and steel market, for the first half of 1919 at least, has now been dispelled by the continued inactivity and by the failure of any signs to develop that favorable conditions are on the way.

During the latter part of January buying of steel products was at a slightly increasing rate, though at the best it was light. In the past fortnight the market has been even more stagnant than formerly.

Steel mill operations have been at an average of about 50 per cent of capacity in the case of the independents, while the Steel Corporation subsidiaries have been operating at about 85 per cent. The difference in rates is not to be ascribed to difference in the character or volume of business on books, but is rather to be attributed to a difference in policy. The independents are making only the material for which they have shipping orders, while the Steel Corporation is putting a considerable portion of its output into stock. At the pipe, wire, sheet and tin plate mills there is storage capacity equal to from four to six weeks of production, and for these products as well as for bars, shapes and plates the Steel Corporation has a line of warehouses from Boston to Chicago and New Orleans. By the close of the war stocks at these warehouses had been reduced to almost nothing. Apparently the Steel Corporation is actuated not so much by a desire to have a reserve of material against increased demand in future as by a desire to give employment to its men, preventing discontent and discouraging the spread of union sentiment, for unionization of the steel industry, on account of its tendency to restrict output, would be extremely harmful.

Economies in Production

While there is economy, as to production cost per ton, in operating at 85 per cent rather than 50 per cent, not a great deal of attention is paid to economies as disclosed merely by the cost sheet, for matters of policy are involved. Thus with basic pig iron held at $30 at furnace and with heavy melting steel available at $16 a ton or thereabouts it would undoubtedly be cheaper to use large percentages of scrap and cut down the consumption of pig iron, and this would apply to a great extent even to the self-contained interests, whose production cost of pig iron is to be considered, rather than the open market price, yet there is no evidence that the proportions of scrap used have increased. Scrap is, indeed, a drug on the market and dealers doubt whether the mills are using as large a percentage as formerly in their open-hearth charges.

Character of Demand

Demand for steel products is entirely along lines of everyday consumption, orders involving permanent construction or investment works being very conspicuous by their absence. Manufacturing consumers generally, making various wares practically for sale over the counter, are buying in a moderate way, but with great conservatism and evidently with a view of maintaining stocks at the lowest possible point. This is true also of jobbers, who buy only for immediate turnover. The automobile makers are taking steel very freely and already have almost attained their former rate of consumption. The buying of electrical sheets is almost entirely confined to material for automobile equipment, indicating that electric motors and generators of large size are in no request, a condition that does not obtain when there is new construction work in progress or in sight, such as involves demand for structural and cognate forms of steel. The agricultural implement makers are taking steel at a fair rate, evidently in expectation of at least moderate demand from the farmers, and steel producers are in expectation of the farmers buying fairly well of fence wire, wire fence, wire nails and sheets, though thus far such buying has been very far from heavy.

Barriers to Activity

Conditions in the steel trade are not peculiar to that industry, but are to be found more or less in industrial activity generally. The barriers to activity apply in particular to works of construction, of the investment character, and as steel passes largely into such permanent works, rather than into items of current consumption, the condition is most pronounced in steel.

The two great barriers to activity, of course, are the failure of prices, or costs, to adjust themselves to prospective conditions, and the menace of bolshevism. Both are equally deterrent influences to the prospective investor, who does not wish his investment to be destroyed or have its earning power reduced, as a spread of bolshevism would threaten, while a decline in the cost of construction work would write a depreciation upon any work completed at the higher cost, and thus tend to decrease its earning power.

The two barriers, high costs and the bolshevist menace, are closely interwoven. The bolshevist menace discourages attempts to reduce costs, although in the long run that would be to the advantage of labor, as it would produce more work.

Steel Industry Helpless

In the circumstances the steel industry is helpless. It cannot bring about better conditions, for the barrier to steel consumption is neither the character nor the price of the steel that is offered for sale. It is the cost of putting steel into consumption, and the uncertainty of reward to the investor after he had put the steel into employment, that prevents buying. It is true that current prices for steel products are too high to furnish a proper basis for a widespread demand, but adjustment in that matter can be effected when it becomes apparent that the need is arising. To cut prices now, little or much, would not increase demand for a time at least, and would indeed at the outset prove discouraging to buyers. With reduced operations mills need very considerable profits per ton to maintain their position, and for the mills to lose money would benefit no one. Of course the salesmen of the steel companies endeavor to prove to customers that steel prices are unlikely to come down much if at all and indeed really simply can't come down much, but such arguments are of only temporary use. There can be scarcely and doubt that eventually, and before there is such a demand for steel as to engage the full mill capacity, there will be very considerable declines in steel prices. The pre-war average will not be attained, but more than half the distance from Government prices of 1918 to the pre-war average will in all probability be traversed.

Prices Firm

Finished steel prices are firmly maintained at the declines that became effective in December, from the Government limits: Plates, 3c.; shapes, 2.80c.; bars, 2.70c.; grooved steel skelp, 2.70c.; blue annealed sheets, 10 gage, 3.90c.; black sheets, 28 gage, 4.70c.; tin plate, $7.35; standard steel pipe, 54 per cent basing discount. Wire remains at 3.25c. and wire nails at $3.50, the Government limits. Billets are $43.50, sheet bars and small billets $47, slabs $46 and rods $57.

Pig iron prices are likewise firmly maintained as follows: Bessemer, $32.20; basic, $30; No. 2 foundry, $31; malleable, $31.50; forge, $30. These prices are, in general, f.o.b. furnace, and represent $3 reduction from Government limits.

Producers experience no difficulty in maintaining prices, as there is no temptation, by way of business offered, to cut prices.

Chemical Market

COAL TAR PRODUCTS:—The position of coal-tar products is somewhat easier and reports from most directions would indicate trading on the whole is in reasonably good volume, but individual sales are of a minor character and buying is still along conservative lines. Buyers are seemingly holding back, anticipating a further decline in prices before bringing their full requirements to the market. Producers are in full accord with this situation, but maintain that their present prices reflect sufficiently well, in view of the costs in production, claiming that labor and raw materials are still maintained at high levels. Among the crudes benzol shows the same steady trend, with trading in reasonably good proportions. Phenol remains in an unsettled condition, while toluol holds close to the levels heard for some time past.

Benzol:—Producers of this commodity have not altered their recent quotations and the situation remains in strong hands with only occasional lots appearing in the resale market.

Phenol:—Trading in this commodity has developed to no unusual proportions, with quantities of the product reaching the resale market at prices as low as 11c. and sales are reported to be passing at this figure.

Toluol:—Consuming demand continues along quiet lines, with offerings through second hands being made at prices 2c. below manufacturers', who have made no changes in their recent quotations.

Dinitrochlorbenzol:—Trading in the general market is in small lots and supplies seem to have accumulated but in no important quantities. Manufacturers have reduced their prices 5c. per pound.

Alpha Naphthylamine:—Price changes to extent of 2c. per pound have been made, but this cut has seemingly had no effect in stimulating business and available supplies are more than sufficient for the current call.

Orthotoluidine:—The market for this commodity has been without special feature for some time back and the continued indifference on the part of consumers is still in evidence. Stocks are in considerable quantities, but prices have not changed since the recent decline.

Dinitrophenol:—There has been a little increase in the general demand for this product since the reduction in the selling schedules last week, but at the present trading is confined to small lots.

Dinitrotoluol:—The lack of consumption requirements has brought about an easier situation so far as stocks are concerned, but prices remain quotably unchanged.

Metanitraniline:—Supplies of this material which are reaching the market are none too liberal, but on the other hand the demand is in proportion, therefore the situation is met without difficulty and prices are firm.

Mixed Toluidine:—A satisfactory movement is generally reported for the product, but individual sales are in small lots and indicate buying is carried along on conservative lines. Prices have not been subject to any material change since the recent decline.

Beta Naphthylamine:—While there is no pronounced activity in this market a fairly steady business is evident, with stocks fully in proportion to the current call and prices are firmly maintained.

Diphenylamine:—The product presents a quiet appearance, with no important interest noted in any single direction. Despite this quietness prices remain at the same firm levels.

Paraphenylenediamine:—Supplies of this material are in fairly good quantities and trading is along conservative lines, but of sufficient volume to take the slack off the market. Dealers who are offering have not altered their recent prices for the various grades.

HEAVY CHEMICALS:—There was not much snap in business during the interval, although there was a fairly good demand evident for some of the items for export purposes, but dealers are looking forward to a larger volume of trading in this direction. Second hands seem to be in full control of the market, which is general during this period of the year, in view of the carry-over of stocks, but manufacturers seem to be more inclined to meet this situation, making an effort to bring about a more equitable condition, although dealers seem to be so overstocked with many of the heavy chemicals that price cutting is active and the entire situation favors the buyer. For instance, bichromate of soda sold in the resale market at 13c. on spot, caustic soda and soda ash sales were consummated at some low levels. Price conditions on the spot were such that pressure on the part of sellers, second hands, developed to such an extent that many of the items were subject to a decline, but this apparently had no effect on stimulating additional business.

Soda Ash:—During the latter part of the week single bag ash was subject to a more active inquiry, but actual transactions were of moderate proportions, with sales being consummated at $1.40 per hundred pounds from the warehouse. Odd lots of barrel material were sold at $1.65 ex-warehouse, with the general quotation ranging from $1.75 to $1.85 per hundred pounds. Double bag ash in the Middle West was subject to virtually no call, therefore exporting of this product has developed to a nominal position.

Caustic Soda:—Odd lot trading seems to have been the feature of this market and the sales noted during the week were for export material, which was sold at prices ranging from $3.20 to $3.25 per hundred pounds f.a.s. Offerings from the warehouse were being liberally made at $3.05 per hundred pounds ex-store, while some scattered lots of material were offered at $3.10 to $3.20 f.a.s. Ground caustic was subject to no unusual call, with offerings by first hands being made at $4.50 per hundred pounds ex-store, while resale material was available at $4.15.

Bleaching Powder:—Comparatively little is heard from buyers of this commodity and the sales noted would indicate purchasing is along conservative lines. However, a fair movement is experienced for export purposes, although demand in this direction is not of such proportions that any difficulty is experienced in meeting the situation. Manufacturers are quoting large domestic drums from works at 2c. per pound, while this price is shaded by second hands for spot goods. Export drums at the works are offered by producers at 2¼c. per pound, with material in the resale market being available at 3c. f.a.s.

Yellow Prussiate of Soda:—Offerings of the material have reached the resale market at prices as low as 26c., with some sales passing at this figure, while the general market quotation ranges from 27c. to 28c.

Permanganate of Potash:—The continued lack of demand has brought about a steady decline in prices for this product, with virtually no interest in the technical variety, and sales for the U. S. P. grade were noted at 95c. per pound. Buyers are seemingly interested in only such lots as are needed for immediate use. Resale lots were offered at prices ranging from $1.00 to $1.05 per pound for the U. S. P.

Bichromate of Soda:—Quiet trading in addition to keener competition among holders who show some anxiety to sell has brought about prices as low as 13c. with actual sales noted at this figure. There were offerings throughout the market at prices ranging from 13½c. to 15c. ex-store.

Chlorate of Potash:—Export trading in this commodity has been sufficiently active to maintain a rather firm market, with no disposition on the part of holders to shade the price of 40c. f.a.s., although there were offerings of the Japanese product at 33c. per pound ex-warehouse.

Cyanide of Soda:—Consuming requirements seem to be sufficient to keep the position of this item firm and available supplies are none too liberal. However, there has apparently been no difficulty experienced in filling orders. Prices are steady at 30c. to 31c. per pound.

Hyposulphite of Soda:—A rather firm situation continues for this item, although the demand is not persistent, but on the other hand stocks are none too liberal in supply. Sellers quote on the former basis of $3.60 for the pea crystals and $3.25 for the regular crystals, per hundred pounds.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET FEB. 8, 1919

Acetic anhydride	lb.	.90 —	1.00
Acetone	lb.	.15½ —	.16
Acid, acetic, 28 per cent	cwt.	3.25 —	3.50
Acetic, 56 per cent	cwt.	6.50 —	6.75
Acetic, glacial, 99½ per cent, carboys	cwt.	14.00 —	14.50
Boric, crystals	lb.	.13½ —	.15
Citric, crystals	lb.	1.25 —	1.27
Hydrochloric, (22°)	cwt.	2.50 —	3.00
Hydrofluoric, 30 per cent, in barrels	lb.	.08 —	.08½
Lactic, 44 per cent	lb.	.14 —	.15
Lactic, 22 per cent	lb.	.06 —	.07
Molybdic, C. P	lb.	6.90 —	7.40
Nitric, 36 deg	lb.	.07 —	.....
Nitric, 42 deg	lb.	.08½ —	.10
Oxalic, crystals	lb.	.36 —	.38
Phosphoric, 47-50 per cent paste	lb.	.07½ —	.10
Phosphoric, ref. 50 per cent	lb.	.35 —	.40
Picric	lb.	.75 —	.85
Pyrogallic, resublimed	lb.	3.25 —	3.50
Sulphuric, 60 deg works	ton	14.00 —	16.00
Sulphuric, 66 deg works	ton	26.00 —	21.00
Sulphuric, oleum (Fuming), tank cars	ton	60.00 —	65.00
Tannic, U. S. P., bulk	lb.	1.40 —	1.50
Tartaric, crystals	lb.	.85 —	.87
Tungstic, per lb. of W	lb.	1.70 —	1.75
Alcohol, sugar cane, 188 proof	gal.	4.85 —	.....
Alcohol, wood, 95 per cent	gal.	1.28 —	1.30
Alcohol, denatured, 180 proof	gal.	.52 —	.54
Alum, ammonia lump	lb.	.05½ —	.06
Alum, chrome ammonium	lb.	.17½ —	.18
Alum, chrome potassium	lb.	.20 —	.22
Alum, chrome sodium	lb.	.12½ —	.13
Alum, potash lump	lb.	.09½ —	.10
Aluminium sulphate, technical	lb.	.02½ —	.02½
Aluminium sulphate, iron free	lb.	.03½ —	.03¾
Ammonia aqua, 26 deg., carboys	lb.	.07 —	.08¼
Ammonia, anhydrous	lb.	.40 —	.45
Ammonium carbonate	lb.	.13 —	.14
Ammonium nitrate	lb.	.16 —	.17
Ammonium, sulphate domestic	lb.	.06 —	.07
Amyl acetate	gal.	3.75 —	4.25
Arsenic, white	lb.	.10 —	.11
Arsenic, red	lb.	.65 —	.70
Barium carbonate, 99 per cent	ton	80.00 —	90.00
Barium carbonate, 97-98 per cent	ton	65.00 —	67.00
Barium chloride	ton	65.00 —	75.00
Barium sulphate (Blanc Fixe, Dry)	lb.	.04½ —	.05
Barium nitrate	lb.	.10 —	.11
Barium peroxide, basis 70 per cent	lb.	.30 —	.32
Bleaching powder, 35 per cent chlorine	lb.	.02 —	.03½
Borax, crystals, sacks	lb.	.08¼ —	.08½
Brimatone, crude	ton	65.00 —	70.00
Bromine, technical	lb.	.65 —	.....
Calcium, acetate, crude	lb.	.04 —	.05
Calcium, carbide	lb.	.10½ —	.11½
Calcium chloride, 7-75 per cent, fused, lump	ton	22.00 —	24.00
Calcium peroxide	lb.	1.50 —	1.70
Calcium phosphate	lb.	.22 —	.23
Calcium sulphate, 98-99 per cent	lb.	.09 —	.09½
Carbon bisulphide	lb.	.08 —	.09
Carbon tetrachloride, drums	lb.	.15 —	.16
Carbonyl chloride (phosgene)	lb.	.75 —	1.00
Caustic potash, 88-92 per cent	lb.	.57 —	.62
Caustic soda, 76 per cent	100 lb.	3.05 —	3.15
Chlorine, liquid	lb.	.10 —	.12
Cobalt oxide	lb.	1.60 —	1.65
Copperas	lb.	.01½ —	.02½
Copper carbonate	lb.	.30 —	.31
Copper cyanide	lb.	.75 —	.78
Copper sulphate, 99 per cent, large crystals	lb.	.08¾ —	.08½
Cream of tartar, crystals	lb.	.60½ —	.63
Epsom salt, bags, U.S.P	100 lb.	2.75 —	.....
Formaldehyde, 40 per cent	lb.	.22½ —	.23
Glauber's salt	lb.	.02 —	.02½
Glycerine, bulk, C.P	lb.	.20 —	.21
Iodine, resublimed	lb.	4.25 —	4.30
Iron oxide	lb.	.06 —	.08
Lead acetate, white crystal	lb.	.17 —	.17½
Lead arsenate (Paste)	lb.	.15 —	.18
Lead nitrate, C. P	lb.	.85 —	.86
Litharge, American	lb.	.11 —	.12
Lithium, carbonate	lb.	1.50 —	2.05
Magnesium carbonate, technical	lb.	.16 —	.17
Nickel salt, single	lb.	.14 —	.15
Nickel salt, double	lb.	.12 —	.13
Phosgene (see Carbonyl chloride)	lb.	.75 —	1.00
Phosphorus, red	lb.	.90 —	.95
Phosphorus, yellow	lb.	.75 —	.80
Potassium bichromate	lb.	.38 —	.40
Potassium bromide granular	lb.	1.25 —	1.26
Potassium carbonate calcined, 85-90 per cent	lb.	.38 —	.40
Potassium chlorate, crystals	lb.	.38 —	.40
Potassium cyanide, 98-99 per cent	lb.	.60 —	.70
Potassium iodide	lb.	3.75 —	3.80
Potassium muriate, 80-85 p. c. basis of 80 p. c.	ton	300.00 —	350.00
Potassium nitrate	lb.	.27 —	.31
Potassium permanganate, U. S. P	lb.	1.05 —	1.10
Potassium prussiate, red	lb.	1.75 —	1.85
Potassium prussiate, yellow	lb.	.62 —	.65
Potassium sulphate, 90-95 p. c. basis 90 p.c.	ton	Nominal	
Rochelle salts	lb.	.46½ —	.48
Salammoniac, gray gran	lb.	.16 —	.18
Salammoniac, white gran	lb.	.14 —	.16
Sal soda	100 lb.	1.75 —	2.00
Salt cake	ton	18.00 —	20.00
Silver cyanide, based on market price of silver	oz.	.....	.....
Silver nitrate	oz.	.63½ —	.64
Soda ash, 58 per cent, light, flat (bags)	100 lb.	1.40 —	1.60
Soda ash, 58 per cent, dense, flat	100 lb.	3.35 —	3.50
Sodium acetate	lb.	.12 —	.13
Sodium bicarbonate, domestic	lb.	.02½ —	.02½
Sodium bicarbonate, English	lb.	..... —	.....
Sodium bichromate	lb.	.14½ —	.15½
Sodium bisulphite, powd	lb.	.12 —	.14
Sodium chlorate	lb.	.18½ —	.19
Sodium cyanide	lb.	.30 —	.35
Sodium fluoride, commercial	lb.	.16 —	.17
Sodium hyposulphite	100 lb.	3.25 —	3.60
Sodium molybdate, per lb. of Mo	lb.	2.50 —	.....
Sodium nitrate, 95 per cent	100 lb.	4.42 —	4.55
Sodium nitrite	lb.	.14 —	.16
Sodium peroxide	lb.	.35 —	.45
Sodium phosphate	lb.	.04 —	.04½
Sodium prussiate, yellow	lb.	.28 —	.30
Sodium silicate, liquid (60 deg.)	lb.	.05 —	.06
Sodium sulphide, 30 per cent, crystals	lb.	.02 —	.03
Sodium sulphide, 60 per cent, fused	lb.	.04½ —	.05
Sodium sulphite	lb.	.05½ —	.06
Strontium nitrate	lb.	.25 —	.30
Sulphur chloride, drums	lb.	.07½ —	.09
Sulphur dioxide, liquid, in cylinders	lb.	.15 —	.40
Sulphur, flowers, sublimed	100 lb.	4.35 —	4.50
Sulphur, roll	100 lb.	3.70 —	3.85
Sulphur, crude	ton	35.00 —	.....
Tin bichloride, 50 deg	lb.	.28 —	.29
Tin oxide	lb.	.75 —	.76
Zinc carbonate	lb.	.18 —	.20
Zinc chloride	lb.	.15 —	.15½
Zinc cyanide	lb.	Nominal	
Zinc dust, 350 mesh	lb.	.13¾ —	.14
Zinc oxide, American process, works	lb.	.10 —	.12
Zinc sulphate	lb.	.04½ —	.06½

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.22 —	.27
Benzol, 90 per cent	gal.	.25 —	.....
Toluol, in tank cars	gal.	.25 —	.....
Toluol, in drums	gal.	.30 —	.35
Xylol, pure, water white	gal.	.45 —	.55
Solvent naphtha, water white	gal.	.20 —	.25
Solvent naphtha, crude, heavy	gal.	.15 —	.17
Creosote oil, 25 per cent	gal.	.45 —	.55
Dip oil, 20 per cent	gal.	.35 —	.40
Pitch, various grades	ton	8.00 —	20.00
Carbolic acid, crude, 95-97 per cent	lb.	Nominal	
Carbolic acid, crude, 50 per cent	lb.	Nominal	
Carbolic acid, crude, 25 per cent	lb.	Nominal	
Cresol, U. S. P	lb.	.18 —	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00 —	1.10
Alpha naphthol, refined	lb.	1.50 —	1.60
Alpha naphthylamine	lb.	.48 —	.50
Aniline oil, drums extra	lb.	.25 —	.27
Aniline salts	lb.	.36 —	.40
Anthracene, 80 per cent	lb.	.50 —	.55
Benzaldehyde (f.f.c.)	lb.	4.25 —	4.50
Benzidine, base	lb.	1.45 —	1.60
Benzidine, sulphate	lb.	1.15 —	1.25
Benzoic acid, U. S. P	lb.	1.80 —	1.90
Benzoate of soda, U. S. P	lb.	1.65 —	1.70
Benzyl chloride	lb.	1.00 —	.....
Beta naphthol benzoate	lb.	5.50 —	6.00
Beta naphthol, sublimed	lb.	.75 —	.85
Beta naphthylamine, sublimed	lb.	2.60 —	2.65
Dichlorbenzol	lb.	.15 —	.20
Diethylaniline	lb.	3.25 —	4.00
Dinitrobenzol	lb.	.36 —	.38
Dinitrochlorbenzol	lb.	.30 —	.35
Dinitronaphthaline	lb.	.55 —	.60
Dinitrotoluol	lb.	.40 —	.50
Dinitrophenol	lb.	.39 —	.45
Dimethylaniline	lb.	.57 —	.65
Diphenylamine	lb.	.75 —	.85
H-acid	lb.	2.35 —	2.75
Metaphenylenediamine	lb.	1.55 —	1.75
Monochlorbenzol	lb.	.16 —	.19
Naphthalene, flake	lb.	.08 —	.09
Naphthalene, balls	lb.	.11½ —	.12½
Naphtionic acid, crude	lb.	1.20 —	1.30
Naphthylamin-di-sulphonic acid	lb.	1.00 —	1.10
Nitro naphthaline	lb.	.45 —	.50
Nitro toluol	lb.	.55 —	.60
Ortho-amidophenol	lb.	6.00 —	7.00
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-toluidine	lb.	.50 —	.90
Ortho-nitro-toluol	lb.	.75 —	.85
Para-amidophenol, base	lb.	3.25 —	3.65
Para-amidophenol, H. C. L	lb.	3.75 —	4.25
Para-dichlor-benzol	lb.	.15 —	.20
Paranitraniline	lb.	1.40 —	1.60
Para-nitro-toluol	lb.	1.50 —	1.60
Paraphenylenediamine	lb.	3.25 —	3.50
Para toluidine	lb.	2.00 —	2.25
Phthalic acid anhydride	lb.	3.25 —	3.50
Phenol, U. S. P	lb.	Nominal	
Resorcin, technical	lb.	4.50 —	5.00
Resorcin, pure	lb.	7.00 —	8.00
Salicylic acid, U. S. P	lb.	.60 —	.....
Salol	lb.	1.50 —	2.00
Sulphanilic acid, crude	lb.	.25 —	.31
Toluidine	lb.	2.45 —	.....
Toluidine-mixture	lb.	.80 —	1.00

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	4.00 —	.....
Corning, Ohio	bbl.	2.85 —	.....
Somerset, Ky	bbl.	2.60 —	.....
Wooster, Ohio	bbl.	2.58 —	.....
Indiana	bbl.	2.28 —	.....
Illinois	bbl.	2.25 —	.....
Oklahoma and Kansas	bbl.	2.25 —	.....
Caddo, La., light	bbl.	2.10 —	2.25
Corsicana, Tex., light	bbl.	2.25 —	.....
California	bbl.	1.24 —	1.57
Gulf Coast	bbl.	1.25 —	.....
Mexican	bbl.	1.90 —	.....

Fuel Oil

New York	gal.	.15 —	.....
Philadelphia	gal.	.10½ —	.....
Baltimore	gal.	.07½ —	.15
Pittsburgh	gal.	.07½ —	.10½
Texas	bbl.	1.85 —	2.35
Los Angeles	bbl.	1.65 —	.....

Gasoline (Wholesale)

New York, motor	gal.	.24½	—	.....
Gas machine	gal.	.41½	—	.....
72-76 degrees	gal.	.33½	—	.39½
70-72 degrees	gal.	.32	—	.37½
67-70 degrees	gal.	.30½	—	.36½
Pittsburgh, motor	gal.	.25½	—	.....
Chicago, motor	gal.	.21	—	.....
Oklahoma, motor	gal.	.23½	—	.....
San Francisco, motor	gal.	.20½	—	.....

Paraffine Waxes

Crude, 103 to 105 deg. m.pt	lb.	.08½	—	.09
Crude, 118 to 120 deg. m.pt	lb.	.09½	—	.10
Crude, 124 to 126 deg. m.pt	lb.	.10	—	.....
Refined, 120 deg. m.pt	lb.	.13½	—	.....
Refined, 128 deg. m.pt	lb.	.14	—	.....
Refined, 135 deg. m.pt	lb.	.16	—	.16½
Ozokerite, brown	lb.	.75	—	.80
Ozokerite, green	lb.	.85	—	.90

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.24	—	.25
Cylinder, light	gal.	.42	—	.44
Cylinder, dark	gal.	.39	—	.43
Paraffine, high viscosity	gal.	.40	—	.41
Paraffine, 0.903 sp. gr	gal.	.36	—	.38
Paraffine, 0 885 sp. gr	gal.	.26	—	.28

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f. o. b. Florida	gal.	.44	—	.....
Pine oil, steam-distilled, sp. gr. 0.925-0.940	gal.	.58	—	.60
Pine oil, destructively distilled	gal.	.58	—	.60
Pine-tar oil, sp. gr. 1.02-1.035	gal.	.35	—	.....
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal	.42	—	.....
Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f.o.b. works	gal.	.37	—	.....
Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.28	—	.....
Pine-tar oil, ref., thin, sp. gr. 1.060-1.080	gal.	.32	—	.....
Turpentine, crude, sp. gr. 0.870-0.900	gal.	.45	—	.....
Hardwood oil, f.o.b. Michigan, sp.gr. 0.960-0.990	gal.	.23	—	.....
Hardwood oil, f.o.b. Michigan, sp.gr. 1.06-1.08	gal.	.23	—	.....
Wood creosote, ref., f.o.b. Florida	gal.	.31	—	.....

Naval Stores

Rosin A-E barrel	280 lb.	13.60	—	13 75
Rosin F-I	280 lb.	13.75	—	14.10
Rosin K-N	280 lb.	16 25	—	16.85
Rosin WG-W	280 lb.	17.00	—	17.25
Spirits of turpentine	gal.	.72	—	.75
Wood turpentine, steam distilled	gal.	.64	—	.65
Wood turnpeatine, destructively distilled	gal.	.63	—	.65½
Pitch	bbl. 200 lb.	8.00	—	.....
Tar, kiln dried	280 lb.	13.00	—	13.50
Retort tar	280 lb.	14 00	—	14.50
Rosin oil, first run	gal.	.77	—	.....
Second run	gal.	.80	—	.....
Third run	gal.	.85	—	.....
Fourth run	gal.	.95	—	.....

Vegetable Oils

Castor oil	lb.	.25	—	.26
Chica wood oil	lb.	.23	—	.24
Cocoanut oil	lb.	.16	—	.21
Corn oil	lb.	.14	—	.....
Cottonseed oil, crude	lb.	.17½	—	.22
Linseed oil, raw, cars	gal.	1.45	—	1.48
Palm	lb.	.18	—	.21½
Peanut oil, crude	lb.	.17½	—	.21
Soya bean oil, Manchuria	lb.	.14	—	.15

Glues

Extra white	lb.	.31	—	.35
Cabinet	lb.	.25	—	.26
Brown foot stock	lb.	.15	—	.19
Fish glue, 50-gal. barrels	gal.	1.00	—	1.50

Miscellaneous Materials

Barytes, floated, white, domestic	ton	33.00	—	36.00
Beeswax, white, pure	lb.	.63	—	.65
Beeswax, unbleached	lb.	.43	—	.48
Blanc fixe	lb.	.05½	—	.....
Casein	lb.	.17½	—	.30
Chalk, light, precipitated, English	lb.	.04½	—	.06
China clay, imported, lump	ton	20 00	—	40.00
China clay, domestic, lump	ton	15 00	—	22.50
Feldspar	ton	8 00	—	12.00
Fluorspar, gravel, f. o. b. mines	ton	28 00	—	40.00
Fluorspar, washed, powdered	ton	90.00	—	.....
Fuller's earth, powdered	100 lb.	1.50	—	2.00
Graphite Alabama	lb.	.08	—	.12
Ceylon	lb.	.09	—	.22
Madagascar	lb.	.10	—	.15
Mexican	ton	35.00	—	75.00
Japan wax	lb.	.18	—	.19
Orange shellac	lb.	.72	—	.80
Pumice stone	lb.	.04	—	.08
Soapstone	ton	15.00	—	25.00
Stearic acid	lb.	.17	—	.19
Talc, American, white	ton	20.00	—	40.00

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	100 00	—	120.00
Chrome cement	net ton	75 00	—	.....
Clay brick, first quality fireclay	per 1000	40.00	—	50.00
Clay brick, second quality	per 1000	35 00	—	40.00
Magnesite, raw	ton	30 00	—	35.00
Magnesite, calcined, powdered	ton	50 00	—	65 00
Magnesite, dead burned	net ton	38 00	—	40 00
Magnesia brick, 9x4½x2½	net ton	110.00	—	125.00
Silica brick	per 1000	45.00	—	55.00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent, carloads, f. o. b. Niagara Falls, N. Y	ton	200 00	—	250.00
Ferrocerium	lb.	15.00	—	30.00
Ferrochromium, per lb. of Cr	lb.	.30	—	.40
Ferromanganese, domestic, 70 per cent basis	ton	150.00	—	200.00
Ferromanganese, English	ton		—	.....
Spielgeleisen (16-18%)	ton	60.00	—	.....
Ferromolybdenum, per lb. of Mo	lb.	3.50	—	4.50
Ferrosilicon, 75 per cent, f. o. b. N. Y	ton		—	.....
Ferrosilicon, 50 per cent, contract	ton	125.00	—	.....
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	Nominal		
Ferrouranium, f.o.b. works, per lb. of U	lb.	7.50	—	.....
Ferrovanadium, f.o.b. works	lb.	.....	—	.....

Ores and Semi-finished Products

Chrome ore, 45 per cent minimum, f.o.b. Cal. per unit	ton	1.50	—	1.55
Coke	ton	6.00	—	7.00
Petroleum Coke	ton	16 00	—	.....
Mangaocse ore, 48 per cent and over, per unit	ton	1.20	—	.....
Manganese ore, chemical	ton	80.00	—	100.00
Molybdenite, per lb. of MoS_2	lb.	1.25	—	1.50
Tungsten, Scheelite, per unit of WO_3	ton	17 00	—	24.00
Tungsten, Wolframite, per unit of WO_3	ton	15.00	—	21 00
Uranium oxide, 96%	lb.	3.25	—	3.60
Vanadium pentoxide, 99%	lb.	10.50	—	.....
Pyrites, foreign	unit	17	—	.....
Pyrites, domestic	unit	.28	—	.30½

Plant Supplies

BUILDING MATERIALS

Common clay bricks	M	14 00	—	15.00
Faced Brick	M	37.00	—	46.00
Hollow tile, 4x12x12	M	60.00	—	.....
Hollow tile, 12x12x12	M	170.00	—	.....
Lime	ton	16.50	—	.....
Portland cement	bbl.	2.59	—	.....
Single glass (82-lb.), 10x26-16x24		21 00	—	27.00
Double glass (164 lb.), 10x26-16x29		31 00	—	39 00
Yellow pine lumber	M	39 00	—	45.00
Cypress	M	70 00	—	.....
Tarred felt (14-lb. sq.)	ton	61 00	—	.....
Roofing pitch	ton	27 00	—	.....
Asphalt coated roofing (35-55-lb.sq.)	sq.	1 60	—	2 45
Slate surfaced asphalt shingles	sq.	5.25	—	5 50
Corrugated galvanized iron	ton	109.00	—	127.00
Putty	100 lb.	6.25	—	.....
Red oxide (Ppte. Copperas)	100 lb.	15 00	—	20.00
Native red oxide	100 lb.	3.25	—	8.00
Red metallic paint	100 lb.	1 20	—	1.50
White lead in oil	100 lb.	15.00	—	16.00
White lead (dry.)	100 lb.	11 00	—	13.00
Red lead in oil	100 lb.	12 28	—	14.50
Red lead (dry)	100 lb.	14 50	—	.....
Zinc oxide (dry)	100 lb.	13 00	—	14.50
Zinc oxide—leaded	100 lb.	9 00	—	10.00
Yellow ochre	100 lb.	1.50	—	10.00
Ultra marine blue	100 lb.	14 00	—	50.00
Prussian blue	100 lb.	135 00	—	150.00
Chrome green	100 lb.	40 00	—	70 00
Paris green	100 lb.	43 00	—	49 00
Mineral black	100 lb.	1 75	—	2.25
Powdered bone black	100 lb.	5 50	—	12 00
Lampblack	100 lb.	15 00	—	45 00
Gas carbon	100 lb.	16 00	—	25 00
Mexican petroleum pitch	100 lb.	1 00	—	2 00
Gilsonite	100 lb.	2 00	—	2.50
Coal tar pitch	100 lb.	.60	—	1.25

STRUCTURAL IRON

Blue annealed sheet iron	ton	77 00	—	82 00
Black sheet iron	ton	90 00	—	96 00
Galvanized iron	ton	101.00	—	131.00
Tern plate, 8-lb. coating	ton	145.00	—	148.00
Tern plate, 15-lb. coating	ton	175.00	—	.....
Tern plate, 25-lb. coating	ton	200.00	—	.....
Tern plate, 40-lb. coating	ton	230 00	—	.....
Tin plate, prime	ton	147 00	—	155 00
Tank plates	ton	60 00	—	65 00
Beams, channels, angles, T's, Z's	ton	56.00	—	60 00
Rivets	ton	88 00	—	92.00
Steel pipe, ¾ to 3-inch	ton	51 00	—	.....
Bar iron and steel	ton	60 00	—	70.00
Chain (1 inch proof coil)	ton	150 00	—	.....
Nails, bolts, nuts, washers	ton	70 00	—	80 00
Tool steel, special alloys	ton	300.00	—	500 00
Bessemer pig iron	ton	32 00	—	35.20
Bessemer steel	ton	43.50	—	47.50
No. 2 foundry	ton	32 90	—	.....
Steel billets (4 x 4)	ton	47.50	—	.....

POWER HOUSE SUPPLIES

Steam packing, rubber duck	lb.	.99	—	1.10
Asbestos, high pressure	lb.	1 76	—	.....
Asbestos, wired	lb.	1.30	—	.....
Asbestos, graphited braid	lb.	1.21	—	.....
Asbestos, wick	lb.	.75	—	.....
Rubber, sheet	lb.	.66	—	.....
Cup grease	lb.	.07	—	.....
Transmission grease	lb.	.07	—	.....
Axle grease	lb.	.04½	—	.....
Gear grease	lb.	.04½	—	.....
Cotton waste	lb.	.08½	—	.11
Hose, underwriters, 2½ in	ft.	.75	—	.....
Hose, air, ¾ in	ft.	.50	—	.60

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Arizona

CLIFTON.—J. Cristy, lessee of the Lazinsky group of mines between Clifton and Metcalf, will build a 250-ton mill at the copper mines here.

GLOBE.—The Gila Monster Mining Co. will build a 50-ton cyanide mill for its Richmond Basin property, seven miles north of here. W. H. Seamon, superintendent.

OATMAN.—The Mossback Mining Co., Kingman, will build a milling plant here this year. Estimated cost, $400,000.

California

OXNARD.—The city trustees plan an election to vote on $140,000 bond issue for the construction of a gas plant.

TURLOCK.—The city trustees contemplate the construction of a new sewage disposal plant. Plans for same have been submitted to the Board of Health for approval.

Colorado

MONTROSE.—J. N. McBride, representing a syndicate of Colorado and Michigan mining men, has acquired an option on the Cash In Mine, Montrose County, and will build a flotation mill.

Connecticut

HARTFORD.—The city will build a filtration plant. Estimated cost, $400,000. C. Mills Soville, superintendent of waterworks.

Florida

FORT LAUDERDALE—The city will install softening and filtration plants in connection with the improvements it plans to the waterworks. Total estimated cost, $30,000. H. C. Davis, city engineer.

Idaho

SALMON.—The Harmony Mines Co., 602 Hearst Bldg., Chicago, Ill., will install a concentration plant and mill at their property here. Estimated cost, $45,000. A. W. Nieman, manager.

Illinois

GILLESPIE.—The village plans to build a water system, to include a filter plant, reservoir and pumping station. Miller, Holbrook & Warren, 517 Milliken Bldg., Decatur, engineer.

SPRINGFIELD.—The city will build a sewage disposal plant. Wade Seeley, City Hall, engineer.

WOODRIVER.—The Standard Oil Co. of Indiana, 910 South Michigan Ave., Chicago, will build an addition to its refinery here. C. B. Manbeck, Woodriver, local manager.

Indiana

EAST CHICAGO.—Bids will be received until February 25 by C. L. Kirk, vice-president of the East Chicago & Indiana Harbor Water Co., 113 Monument Circle, Indianapolis, for the construction of a water purification plant, consisting of chemical house, filter house, boiler house and pumping plant addition, sedimentation basins and filtered water reservoir.

Louisiana

BATON ROUGE.—The Illinois Central R.R., Central Station, Chicago, Ill., has awarded the contract for the construction of a one story, 25 x 40 ft. filtration plant, having a capacity of 25,000 gallons per hour, to the Graver Tank Works, 4809 Todd Ave., Chicago, Ill. Estimated cost, $18,000.

Maryland

BALTIMORE.—The city will build a filtration plant. Estimated cost, $25,000. J. W. Lee, city engineer.

Massachusetts

ASHLAND.—The United States Color & Chemical Co., 15 Custom House, Boston, will build a three story, 44 x 84 ft. research building here.

Minnesota

MOUNTAIN IRON.—The Board of Education will install a filter and purification plant for swimming pool, in connection with the 3 story, 145 x 173 ft. school which it plans to build on Main St. Total estimated cost, $200,000. H. C. Mitchell, secretary.

Mississippi

PASCAGOULA.—The City Commissioners will receive bids until Mar. 11 for the construction of sanitary and storm drainage sewers to include a sewage disposal plant. Xavier A. Kramer, Magnolia, engineer.

Missouri

ST. LOUIS.—The Floor Shine Paint & Varnish Co., 2744 Olive St., will build an addition to its factory. Estimated cost, $30,000.

Nebraska

OMAHA.—The Omaha Refining Co., Theatre Building, will build oil refinery consisting of two buildings, two stories. 24 x 80 ft. each, at East Omaha. Estimated cost, $10,000. D. W. Lennox, 460 Brandeis Theatre Building, engineer.

New Jersey

MILLTOWN.—The Elizabethtown Water Co., 68 Broad St., Elizabeth, will build a filter house and pumping station here. Estimated cost, $150,000.

NEWARK.—The Department of Streets and Public Improvements has recommended that City Council issue $250,000 bonds for the construction of a garbage disposal plant; plans include the construction of two small incinerators and a reduction plant.

PHILLIPSBURG.—The city will build a sewage purification plant. Estimated cost, $500,000. C. E. Tilton, city engineer.

New York

BROOKLYN.—The State Hospital Commission, Capitol, Albany, will receive bids until Feb. 19, for building a sewage disposal plant at the Creedmoor Division of the Brooklyn State Hospital. Estimated cost, $30,000. Noted Oct. 15.

BUFFALO.—The University of Buffalo, 24 High St., will build a chemical laboratory. About $150,000 available for same.

NEW YORK.—The Commissioner of Water Supply, Gas & Electricity, Municipal Building, received bids Feb. 5 for furnishing and delivering liquid chlorine, from the Hooker Electro Chemical Co., 40 Wall St. $7955; Arnold Hoffman Co., Inc., 55 Canal St., Providence, R. I., $8295; Electro Bleaching Gas Co., 18 East 41st St., $8395; furnishing and delivering chloride of lime, from Arnold Hoffman Co., Inc., 55 Canal St., Providence, R. I., $1095; Knickerbocker Supply Co., 147 Church St., $1437; H. Greenberg, 120 Broadway, $1554. Noted Feb. 1.

ROCHESTER.—The city will build a sewage disposal plant, in the 23rd Ward near the Rome, Watertown & Ogdensburg R.R. bridge. Estimated cost, $30,000.

POUGHKEEPSIE.—The State Hospital Commission, Capitol, Albany, will soon award the contract for improving and enlarging water system at the Hudson River State Hospital here involving the building of an intake crib in the Hudson River thence to filters, changing water main and reservoir. Estimated cost, $40,000. L. F. Pilcher, state architect. Noted Feb. 15.

UTICA.—The State Hospital Commission, Capitol, Albany, will receive bids until March 4 for the construction of a two story, 44 x 60 ft. laboratory and mortuary at the State Hospital here. Estimated cost, $50,000. Noted Jan. 15.

WATERTOWN—Knowlton Bros., 139 Mill St., will build an addition to its paper mill. Estimated cost, $50,000. C. Eaton, Sherman Building, engineer.

North Carolina

WILMINGTON.—The city has awarded the contract for building four filter unit each having a daily capacity of 400,000 gallons, to the Pittsburgh Filter Co., Farmers Bank Building, Pittsburgh, Penn. Estimated cost, $50,000.

Ohio

OBERLIN.—The Board of Education is having plans prepared by F. C. Warner, architect, 767 Hippodrome Annex, Cleveland, for the construction of a two story, 75 x 180 ft. high school building, to include chemistry, botany and agricultural laboratories, etc. Total estimated cost, $225,000.

Oklahoma

BILLINGS.—The Greater Oklahoma Oil Corporation will build a refinery having a capacity of 2000 barrels, and is in the market for tanks, pumps and stills. G. B. Shirrett, president.

Pennsylvania

ERIE.—The city will construct an intercepting sewerage system and a sewage disposal plant. Chester & Fleming, Union Bank Building, Pittsburgh, engineer.

TIDIOUTE.—The National Gasoline Co., recently organized with a capital of $200,000, will build a large refinery here.

Rhode Island

PROVIDENCE.—The Public Building Commission, City Hall, will install a chemical laboratory in the three story, 300 x 170 ft. high school building which it plans to construct on Pond St. Total estimated cost, $500,000. Hoppin & Field, 32 Westminster St., architect.

South Carolina

CHARLESTON.—The Eitwan Fertilizer Co. will rebuild its two story acid chambers on the Cooper River recently destroyed by fire. Estimated cost, $125,000. F. Burledge, president.

Texas

FORT WORTH.—The Panther City Oil & Refining Co. will build an oil refinery, having a daily capacity of 10,000 barrels. W. B. Townsend, Flatiron Building, president.

HOUSTON.—The Crown Oil Co. has awarded the contract for the construction of an oil refinery on the Houston Ship Channel, to the W. C. Hedrick Construction Co. Estimated cost, $750,000. Noted Dec. 15.

Virginia

MONEY POINT (Gilmerton P. O.)—The Hubbard Fertilizer Co., 802 Keyser Building, Baltimore, Md., has awarded the contract for the construction of a one and two story, 150 x 192 ft. fertilizer plant here, to W. J. Gregory, 501 Law Building. Estimated cost, $50,000.

NEWPORT NEWS.—The Construction Division of the War Department, Washington, D. C., will build a sewage disposal plant and septic tank at Camp Alexander, here. Estimated cost, $20,000.

West Virginia

ELKINS.—The city will install a filtration system. Address A. M. Wardle, Sanitary Branch of the State Health Department, Charleston.

Wisconsin

MENASHA.—The Lakeside Paper Co. will build an addition to its paper mill. Estimated cost, $80,000.

RICE LAKE.—Stein, Hirsch & Co., 111 West Washington St., Chicago, Ill., will build an addition to its starch factory here. Estimated cost, $200,000.

British Columbia

KASLO.—The Gibson Mining Co. will build a concentrator plant. Estimated cost $25,000. C. D. Empfield, secretary-treasurer.

VANCOUVER.—The L'Air Liquide Societe, 1 Ernest St., Montreal, Que., has awarded the contract for the construction of a two story, 75 x 85 ft. factory, on 5th and Yukon Sts., to S. J. Newitt, 954 17th St., W. Estimated cost, $25,000.

Manitoba

WINNIPEG.—The Legislation Committee of the City Council will build a pulp and paper mill to be owned by the city. Estimated cost, $3,000,000. F. O. Fowler, is interested.

Ontario

BRAMPTON.—The town will install a filtration and sterilization plant. A. E. Davis, clerk.

Quebec

CAP DE LA MADELINE.—The Riverside Lumber Co. will build a pulp mill here. Estimated cost, $200,000. H. Bierman, manager of the Canadian-Belgo Pulp & Paper Co., Shawinigan Falls, is interested.

GRAND MERE—The Laurentide Co., Ltd., McGibbon and 3rd Aves., will build a paper mill. Estimated cost, $400,000. George Cahoon, president.

Ontario

OTTAWA.—The Board of Control has applied to the City Council for authority to issue $100,000 debentures for the construction of laboratories and nurses' quarters at the Royal Ottawa Sanatorium. A. F. MacCallum, City Hall, Ottawa, engineer.

Coming Meetings and Events

THE AMERICAN ELECTRO-PLATERS' SOCIETY, NEW YORK BRANCH, will have its 10th annual hanquet at the Broadway Central Hotel, Saturday, Feb. 22, at 7:30 p. m.

THE AMERICAN INSTITUTE OF MINING ENGINEERS, which includes the Institute of Metals Division, will meet at the New York Headquarters, 29 West 39th St., Feb. 17 to 20 inclusive.

THE CANADIAN MINING INSTITUTE will hold its twenty-first annual meeting on March 5 to 7, 1919.

THE SOCIETY OF INDUSTRIAL ENGINEERS plans a national conference at New York March 18-21 at the Hotel McAlpin, at which there will be a discussion of labor by both employers and labor leaders. Internal plant organization and also the elimination of fatigue will be other leading topics.

Industrial Notes

THE NEW JERSEY ZINC CO. announces the removal of its general offices to 169 Front St., New York City.

COLGATE & CO., 72 and 74 Grand Street, Jersey City, had an explosion on Feb. 4 in its laboratory which killed two men and injured seven, due to an electric spark igniting fumes of ether. Dr. George Pierce, a chemist, who was working with chemicals used in the manufacture of toilet preparations, was one of the victims.

PASQUALE NIEKE & Co., Scoli D'Azeglic 7, Leghorn, Italy, handles the importation of machinery and tools and certain lines of chemicals, particularly nitrates, phosphates and sulphates. The company would like to establish connections with American manufacturers in these lines.

THE PORTUGUESE IMPORT & EXPORT CO., LTD., Rua dos Douradores 83, Lisbon, Portugal, would like to correspond with American firms engaged in the sale of heavy chemicals with a view to becoming representatives.

THE METAL & THERMIT CORP., New York City, announces the appointment of Mr. Arthur F. Braid as sales manager of the metal and alloy department. Mr. Braid started with this company seven years ago as a traveling salesman, but after a few years of service in that capacity he was appointed assistant superintendent of the Jersey City plant, in charge of the manufacture of carbon-free metals and alloys. When the United entered the war, he assumed active charge of the metal sales at the New York office of the company.

FACTORY PRODUCTS CORP., 2 Rector St., New York City, announces its organization for general export and import trade. It has acquired the business and goodwill of the Factory Products Export Corp. and the Manufacturers' Agents Co., Inc. The association of Bonbright & Co., Inc., will continue as financial agents for the consolidated companies. A new department for exportation of engineering supplies, machinery, hardware and building materials will be operated in association with the Engineers Corp., a subsidiary of the J. G. White Engineering Corp. of New York.

THE LIBERTY NATIONAL BANK of New York has created an industrial department for the purpose of offering advisory service on matters pertaining to manufacturing and industrial problems. The new work will be directed by Mr. Donald D. Davis, who has had practical engineering, accounting and factory executive experience.

WARREN, WEBSTER & Co., announce the opening of an office at 805 Sumpter Building, Dallas, Tex., with Mr. W. B. Irwin in charge as district representative.

BUTLER & HAYES, INC., has opened an office at 220 Devonshire St., Boston, Mass., as mechanical and chemical consultant and experimental engineer. The testing laboratories are fully equipped for the study of industrial problems.

THE AMERICAN BOSCH MAGNETO CORPORATION is the official name of the former Bosch Magneto Co., which was recently sold by the Alien Property Custodian of the United States to the highest bidder. The entire holdings and organization, including the Bosch works at Springfield, Mass., have been taken over and the large output will now be devoted entirely to the requirements of American manufacturers and the public.

THE EDISON STORAGE BATTERY CO., New York City, announces the removal of its New York sales office from 209 West 76th Street to 247-251 West 35th Street.

THE ELECTRIC STEEL CO. OF INDIANA has opened an office in the Penobscot Building, Detroit, Mich., with Mr. A. J. Kinnucan as district manager.

Manufacturers' Catalogs

THE HEINE SAFETY BOILER CO., St. Louis, Mo., has just received from the press the latest edition of "Boiler Logic," an 86-page treatise on steam boilers, with a supplement in color of a Heine boiler set over an underfeed stoker. This interesting catalog covers: I. Some fundamental considerations of boiler design; II. Practical baffling of water-tube boilers; III. Heine boilers for different fuels, firing and services; IV. Overloads; V. The boiler as a pressure vessel, and VI. Details of construction of the boilers.

THE COKAL STOKE CO., Chicago, Ill., has issued two pamphlets on its stokers.

THE STEERE ENGINEERING CO., Detroit, Michigan, calls attention to Bulletin No. 36, dealing with plant models. This 16-page booklet illustrates and describes practical methods employed in analyzing and determining the purchaser's requirements.

THE LAKEWOOD ENGINEERING CO., Cleveland, Ohio: Bulletin No. 26 pictorially describes clamshell buckets, diggers and handlers, and gives general data as to type-size, load, water level, thickness of shells, weight, diameter of sheaves, cable size recommended, amount of cable overhauled, lifting speed per minute and horse power required together with descriptions of the different types.

THE QUIGLEY FURNACE SPECIALTIES CO., New York City, calls attention to Bulletin No. 10 which treats of the air transport system for transporting and burning powdered fuel.

New Publications

THE JOURNAL OF THE AMERICAN STEEL TREATERS SOCIETY OF CHICAGO has appeared and promises to contain valuable information, particularly for steel metallurgists. Mr. A. F. MacFarland, metallurgist, U. S. Ball Bearing Mfg. Co., Chicago, is chairman of the publication committee. The Journal will appear each month and will represent the activities of the American Steel Treaters Society of Chicago. Mr. T. E. Baker, production engineer, Miehle Printing Press & Manufacturing Co. of Chicago, is president, and Mr. A. G. Henry, metallurgist, Illinois Tool Works, Chicago, is secretary-treasurer.

THE MANUFACTURER'S WAGE PROBLEM. By Herbert F. Perkins of the International Harvester Co. This pamphlet is published by the Union League Club of Chicago and can be purchased from them at 5c. per copy.

NEW U. S. GEOLOGICAL SURVEY PUBLICATIONS: I:A, The Economic Limits to Domestic Independence in Minerals. By George Otis Smith. (Mineral Resources of the U. S., 1917, Part I), published Dec. 28, 1918. I:B, International Control of Minerals. By C. K. Leith. (Mineral Resources of the U. S., 1917, Part I), published Dec. 31, 1918; I:10, Magnesium in 1917. By Ralph W. Stone. (Mineral Resources of the U. S., 1917, Part I), published Dec. 11, 1918; II:20, Peat in 1917. By C. C. Osbon. (Mineral Resources of the U. S., 1917, Part II), published Dec. 19, 1918.

NEW BUREAU OF MINES PUBLICATIONS: War Mineral Investigations Series No. 7, Review of the Manganese Situation. By C. M. Weld, dated Dec., 1918; No. 5, Production of Ferromanganese in Blast Furnaces. By P. H. Royster, prepared in co-operation with the School of Mines of the University of Minnesota, dated December, 1918; An Absorption Method for the Determination of Gasoline in Natural Gas. By W. Y. Dykema and Roy O. Neal of the Bartlesville Station of the Bureau of Mines.

THE UNITED STATES TARIFF COMMISSION has issued its second annual report for the fiscal year ended June 30, 1918. The Commission has continued its preparation of a tariff information catalog for the purpose of facilitating legislation by Congress. The Commission has published several handbooks on different industries and has a number of others in preparation. The chemical and metallurgical industries have received special attention in the commodities that have been covered thus far by the Tariff Information Catalogs.

Stocks and Bonds

Closing Bid and Asked Quotations Feb. 13, on N. Y. Stock Exchange

CHEMICAL COMPANIES

	Bid	Ask		Bid	Ask
Am. Ag. Ch...	100⅛	101	Mat. Al. Wk.	34	44
do. pf.	99	99½	Tex. C. & C.	12⅛	13
Barrett Co.	114	115	Un. Dyewood	60	61
do. pf.	109½	111	do. pf	90	95
Gen. Chem.	164	....	Va.-Car. Ch.	51⅛	51½
do. pf.	103	108	do. pf.	112½	113¼
Int. Ag. Ch..	13½	15			
do. pf.	56½	58			

Bonds

Am. Ag. Ch., 1st cv. 5s, '28	100½	100⅝
Am. Ag. Ch., cv. db. 5s, '24	100⅛	100⅛
Int. Ag. Ch., 1 mtg. & col. tr. 5s, '32	79½	80
Va.-Car. Ch., 1 mtg. 5s, '23	95⅛	96
Va.-Car. Ch., cv. db. 6s, '24	101⅛	102

PETROLEUM COMPANIES

	Bid	Ask		Bid	Ask
Asso. Oil Co..	71	74	P-A Pet & Tr	69½	69⅝
Cal. Pet.	23⅛	23⅜	do. pf.	120	125
do. pf.	68	69	Pierce Oil	17⅛	17½
Col. G. & E.	49¼	49½	Royal Dutch	85	85⅛
Mex. Pet.	172⅛	172⅝	Sinclair O & R	34⅛	34⅜
do. pf.	103½	107	Texas Co.	189½	190½
Ohio Cit. Gas.	39⅛	39⅜	Tex. Pac. Ld. Tr.	220	265
do. pf.	....	....			
Ohio Fuel S	43⅛	44½	Tidewater Oil	215	225
Okla. P. & W.	8⅛	8½			

Bonds

Columbia Gas & Electric, 1 5s, '27	80⅛	82⅛
Col. G. & El., std. 1 5s, '27	81½	....
Pan-Am. Pet. & Tr. 1 6s, '19-'27	112½	....
Pierce Oil, cv. db. 6s, '24	91½	91⅞
Pierce Oil, cv. 5% Notes, '20	100⅜	101
Sin. O. & R. 1 ln. 7s, '20, with stk. war.	98⅛	99
Sin. O. & R. 1 ln. 7s, '20 without stk. war.	95⅛	96
Texas Co., db. 6s, '31	101½	102
Union Oil of Cal. 1 5s, '31	93	93½
United Fuel Gas 1 mtg. 6s, ser. A, '36	95	98

IRON AND STEEL SECURITIES

	Bid	Ask		Bid	Ask
Am. St. F.	76	76½	Pitts. Ste. pf.	92½	92⅞
Beth. Steel	60⅛	61⅛	Rep. Iron & Steel	73	73⅛
do. class B.	60⅛	60⅞	do. pf.	101⅛	101⅜
do. pf., 8%	103⅛	103⅞	Sloss Sheff. I. & S.	48	48⅛
do. pf., 7%	90	95	do. pf.	....	88
Central Fdry.	17	23	Superior Steel	33⅛	34½
do. pf.	31	33⅛	do. 1 pf.	93	101
Col. F. & I.	36	36⅛	Trans. & W. Steel	37⅛	38⅛
do. pf.	100	....	Un. Alloy St.	39	39⅛
Cruc. Steel	54⅛	54⅞	U. S. C. I. P. & F.	15⅛	15⅞
do. pf.	90	94	do. 1 pf.	46⅛	46⅞
Great No. Ore	37⅛	37⅞	U. S. Steel	90⅛	90⅞
Gulf Sta. Steel	50	51	do. pf.	114⅛	114⅞
do. 1 pf.	94	99⅛	Va. Coal, I&C	55	60
Lack. Steel	64⅛	65			
Mid. St. & Ord	41⅛	41⅞			
Nova Scotia Steel	48	....			

Bonds

Beth. Steel, 1 ext. gtd. S. F. 5s, '26	95⅛	96⅛
Beth. Steel, 1 ln. ref. 5s, Ser. A, '42	84⅛	89
Beth. Steel, P. M. & I. S. F. 5s, '36	81	85⅛
Buff. & Susq. Iron, 1 S. F. 5s, '32	85	96
Buff. & Susq. Iron, deb. 5s, '27	....	....
Cent. Found. 1 mtg. S. F. 6s, '21	80	82
Col. F. & I., gn. S. F. 5s, '43	88	90
Ill. Steel, deb. 4½s, '40	84½	85½
Ind. Steel, 1 mtg. gtd. 5s, '52	98⅛	98⅛
Lack. Steel, 1 5s, '23	97⅛	98
Lack. Ste., 1 con. mtg. cv. 5s, Ser. A, '50	86	86½
Mid. St. & Ord., clt. cv. S. F. 5s, '36	86½	87
Nat. Tube, 1 mtg. gtd. 5s, '52	97	98
Rep. I. & S., S. F. mtg. 5s, '40	94⅛	95⅛
Tenn. C. & I. R. R., gn. 5s, '51	91	95½
U. S. Steel, S. F. 5s, '63	100⅛	100⅛
Va. C., I. & C., 1 5s, '49	87	89½

Published SEMI-MONTHLY *on the* FIRST *and* FIFTEENTH *of each month*

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

McGRAW-HILL COMPANY, INC.
Tenth Avenue at 36th Street
NEW YORK

JAMES H. McGRAW, President
ARTHUR J. BALDWIN, Vice President E. J. MEHREN, Vice President
J. MALCOLM MUIR, Vice President EDWARD CALDWELL, Treasurer
JAMES H. McGRAW, JR., Secretary

TELEPHONE 2840 Greeley CABLE ADDRESS, Machinist, New York

WASHINGTON, Colorado Bldg. SALT LAKE CITY, Newhouse Bldg.
CHICAGO, Old Colony Bldg. PHILADELPHIA, Real Estate Trust Bldg
SAN FRANCISCO, Rialto Bldg CLEVELAND, Leader-News Bldg.
LONDON, 6 Bouverie St., E. C. 4.

H. C. PARMELEE, Editor
ELLWOOD HENDRICK, Consulting Editor
ERNEST E. THUM, Western Editor
WALLACE SAVAGE, Assistant Editor

Yearly Subscription price for United States, Mexico and United States dependencies, $3; all other countries, $4. Single Copy, 25c.
When change of address is ordered, the NEW and the OLD addresses must be given. Notice must be received at least 10 days before change takes place. No back copies for more than three months.

Copyright, McGraw-Hill Co., Inc., 1919. Entered as second-class matter, July 13, 1918, at the Post Office at New York, N. Y., under the Act of Congress of March 3, 1879.

Circulation of this issue 12,250 copies

CONTENTS *for March* 1, 1919

Volume XX, *Number* 5

EDITORIAL
Post-War Meetings of Scientific Societies....201
Validation of Informal Contracts....201
Abolish Duty-Free Imports of Chemicals....201
Favorable Prospect for Water-Power Legislation....202
Progress in Zinc Smelting Awaits Impulse From Metallurgists....202
Hard Times for Inventors....202
Iron and Steel Production in 1917....203
READERS' VIEWS AND COMMENTS
The Present Status of Oil Shales. By *Louis Simpson*....204
Instituto Cientifico Industrial del Salitre de Chile. By *Belisario Diaz Ossa*....205
Classifying the Perkin Medalists. By *R. K. Strong*....205
Western Chemical and Metallurgical Field....206
New York Meeting of the American Institute of Mining Engineers....208
Government's Policy in Sale of Surplus Supplies....215
Flakes in Alloy Steel....216
Prize Essay Contest in Industrial Economics....219
Import and Export Statistics....219
Linseed Production in Argentina....220
Important Meetings of Chemists and Electrochemists....220
Industrial Use and Limitations of Respirators, Gas Masks and Oxygen Breathing Apparatus....220
Summary of the Tin Situation by the Geological Survey....221
Concrete as a Chemical Engineering Material. By *Maximilian Toch*....222
Milling Calculations. By *Robert S. Lewis*....225
Navy Department to Sell Explosives Plant....233
Storage Tanks Made of Reinforced Concrete. By *F. W. Frerichs*....234
Plan to Dispose of Government-Owned Nitrate....236
Economics of the Zinc Industry: A Prophetic Discussion. By *Parker C. Choate*....238
Corrosion of Brass in Sea Water. By *Paul T. Bruhl* 239
Laboratory Electro-Deposition Plant. By *Carl R. Hayward*..240
Fuel Economy in the Boiler House—II. By *John B. C. Kershaw*....241
Eliminating Phosphorus and Sulphur in Electric Ferromanganese Furnaces. By *Jay Lonergan*....245
Determining Zero Reading on an Ellison Gage. *By Herman Bacharach*....246
Points in Pump Selection. By *B. N. Everett*....246
Recent Chemical and Metallurgical Patents....248
Personals....249
Obituary....250
Current Market Report—Non-Ferrous Metal Market, Iron and Steel Market, Chemical Market and Chemical Price List..250
Industrial News—Plant Construction, Coming Meetings and Events, Catalogs, New Publications and Industrial News..255

Post-War Meetings of Scientific Societies

WE NOTE the approaching sessions of two important conventions which have special interest for chemists and electrochemists. The American Electrochemical Society will meet in New York, April 3-5, and will make a special feature of papers on subjects that were taboo during the war, but on which information has now been released. Considering electrochemistry's notable contributions to modern warfare, we may look for announcements of intense interest. In the following week, April 8-11, the American Chemical Society will meet at Buffalo and will give special consideration to needed Congressional legislation with relation to the chemical industry. Both meetings will reward attendance by members of the profession.

Validation of Informal Contracts

THERE is prospect of immediate legislation that will afford relief to those who were engaged in the production of munitions of war when armistice was declared, and who found themselves embarrassed by the non-existence of formally executed contracts with the Government. Although Government officials recognized that many of these agreements were *bona fide*, the Comptroller of the Treasury refused to recognize the obligation and the contracts were outlawed on technical grounds. Representations were immediately made to Congress, and several bills were introduced. The House and Senate passed different bills, but conferees have drafted a new bill which they will recommend for passage. According to its terms, claims must be presented before June 30, 1919. The Secretary of War will be authorized to settle obligations for war supplies, and the Secretary of the Interior will be authorized to discharge agreements, express or implied, with those producers of ores named in the so-called War Minerals Bill, the production of which was urged or demanded by Governmental agencies.

Abolish Duty-Free Imports of Chemicals

EACH succeeding National Exposition of Chemical Industries has emphasized the growing independence of our country in chemical matters, until the idea has become fairly well grounded. If the familiar German label has not become abhorrent for any other reason, its discovery on chemicals used by the enemy in gas warfare should make it an outlaw in respectable laboratories. We have only ourselves to blame, however, for the inculcation of the idea that Germany alone could supply our laboratory needs, and particularly those of

our schools, colleges and universities. By Congressional legislation we have permitted educational and similar institutions to import chemicals and apparatus duty-free, until the number of such availing themselves of this privilege in 1914 was probably in the neighborhood of 10,000! Imports of this class were valued at $572,726 in the fiscal year 1913, and at $704,496 in 1914. We believe we voice the patriotic sentiment of every educational institution when we say that Congress should repeal that clause of the tariff which permits the duty-free importation of chemicals and apparatus, and thus encourage American industry in its willing efforts to meet our own needs. It may cost more money for a time, but the additional expense will be welcome and we can find solace in the knowledge that we can shortly build up a million-dollar industry where little or nothing existed before. American manufacturers have shown their ability and their readiness immediately to supply our schools with American products. American teachers undoubtedly are ready and willing to patronize them. It remains only for Congress to act, and that should be done speedily before German agents begin to reconstruct their lost markets.

Favorable Prospect for Water-Power Legislation

AT THE hour of going to press advices from Washington announce the agreement of House and Senate conferees on provisions for water-power legislation. It is expected that a report will be made to both bodies on or before March 1, and unless there is a filibuster against the bill there is every prospect that it will be passed. The principal provisions do not differ greatly from those previously reported in CHEMICAL & METALLURGICAL ENGINEERING. The control of water-power development is vested in a committee of the Secretaries of the Interior, War and Agriculture. The definition of net investment with relation to recapture of water-power projects by the Government at the end of a fifty-year license period remains practically unaltered. If we are so fortunate as to secure a water-power bill from this session of Congress it will constitute one of the most important steps that could be taken toward reconstruction along sound and substantial lines.

Progress in Zinc Smelting Awaits Impulse From Metallurgists

EVERY zinc metallurgist, worthy of the name, has schemes similar to those of Mr. CHOATE presented elsewhere in this issue, and can hardly wait for the opportune moment when some of the more apparent drawbacks to the present industry can be replaced by more efficient and more modern methods. However, they are almost invariably entirely occupied in keeping the existing plants going, and therefore most of the plans unfortunately remain "dreams."

Mr. CHOATE'S many proposals are worthy of careful consideration and free discussion, but the best results would necessitate the disclosure of practical experiences from a very large number of zinc metallurgists. Such a discussion would be of enormous value indeed! Obvious impediments have so far stood in the way. Thus, in practically all companies the capital is represented by non-technical men who veto the exchange of confidences between the technical staffs. These directors have not yet realized that their mistaken secretiveness excludes ten new ideas from their organization for each quasi-trade secret impounded, while on the other hand the "open door" has done much to advance such as the Phelps-Dodge Corporation to the forefront of copper smelting. Granted that the first duty of the individual operators is to their respective employers, still they can take the first move toward turning the zinc industry from the approaching cul de sac by continually bombarding the management with the idea that at the very worst an interchange of ideas could not make the situation any more difficult.

Advance in zinc smelting has been slow not because the metallurgists have been unwilling or unable to improve the practice—a frequent reproach—but because the large appropriations necessary for experimentation have been denied them. Zinc plants are still built in comparatively small units, the tonnage treated is greatly inferior to that of smelters producing the other common metals, and large capital investments have ordinarily been absent. The one exception to this rule is the Anaconda Copper Mining Co., which by unstinted expenditure of funds and talent accomplished very excellent results along an entirely new and most difficult line of metallurgy, namely, by the electrolysis of sulphate solution. Under similar circumstances others in the profession could no doubt accomplish similar results, and along different lines.

Every one feels the pressing need; the favorable moment has arrived; metallurgists should embrace it to force, if need be, halting recognition of their latent capabilities.

Hard Times For Inventors

THE INCOME tax certainly does pinch a fat pocketbook! It is a fashion of the day, and there is no use protesting; but its probably constitutional, although approximately confiscatory, features in relation to large incomes are likely to slow down the machinery of industrial progress. Every new idea must pass through a speculative phase before it becomes established. The man of limited income cannot afford to speculate. The consensus of human experience is against it. If he has a little something set aside for a rainy day or to provide for old age, he should not play fast and loose with it. With all our reforms and changes in public policy we have not yet reached the point at which we discourage thrift.

Rich men can afford to speculate. They set aside what they are willing to lose, and "take fliers" with it. It is by means of such excess wealth that most new enterprises have been started, and these make for competition, as well as for industrial progress, while they bring down prices in the end. We are not praising rich men, or making any plea for an increase in millionaires; we are merely stating the fact that new enterprises are usually started by savings of the well-to-do; by means of funds that are or should be available for speculation.

Corporations may speculate on new methods, processes and materials within reason. The means for this is taken from research funds. But corporations are slow to change factory practice, and we could fill all our pages with testimonials taken from inventors of

the day to prove that novelties and improvements are hard to get through the front door of industry. It is generally admitted to be wholly useless to offer patents of any kind to certain corporations. We are not complaining; we are merely recording the experiences of the past. As instances of the difficulty of getting even great inventions over the speculative stage we may mention HALL with his aluminium process, or HERMAN FRASCH'S conquest of the sulphur problem in the Gulf States. We should probably still be without sulphur if it had not been for H. McK. TWOMBLY, MRS. HEWITT, and a few others who took a flier on backing the Frasch process.

Banks are not allowed to speculate, but banking institutions by their affiliations with persons of wealth can offer them the opportunity to speculate of their own free will. That is the way in which great promotions have been effected. It comes right back to the rich men again.

Although hope may spring eternal in the human breast, few of us like a treadmill. The incentive to make money only to see it taken away again by taxation is, somehow, not very strong. Possibly it should be great and patriotic, but it is not so regarded. Nobody goes up to the tax-collector's office joyfully and with a brass band. The whole proceeding has never yet acquired charm. Therefore rich men are growing wary of taking fliers in new enterprises, on the ground that, if they lose, their money will be gone, and if they win their profits will be taken away by taxes. They are less inclined toward new things that look good. And the inventor is having a hard time of it.

Iron and Steel Production in 1917

APART from the pig iron and steel rail statistics for 1917, the industry's production statistics for that year are belated and have appeared only in the past fortnight, the delay, of course, being due to the fact that there was more important work on hand, by way of winning the war. Despite their age the figures are quite interesting.

The total production of steel ingots in 1917 was 43,619,200 gross tons, in close keeping with estimates already made and comparing with 41,401,917 tons in 1916, previously the record year. Production in 1906 was 22,624,431 tons, or more than 3,000,000 tons in excess of the best previous output, so that production almost doubled in eleven years. There was more than a doubling from 1905 to 1916.

The production of steel castings in 1917 was 1,441,407 tons, showing an increase of 5 per cent over 1916, previously the record year. From 1906 to 1917 the production of steel castings practically doubled, yet that was really no remarkable record, considering the enormous field of iron castings from which the steel casting could draw if, as some of its votaries used to think, it was going to displace the iron casting in so many uses. Beyond question the steel casting serves an extremely useful purpose in many connections, but the uses do not run into tonnage to the extent that is expected by many.

What is commonly called for statistical purposes "the production of steel" was 45,060,607 tons in 1917, that being the sum of the production of steel ingots and of steel castings. So far as its weight goes, the steel casting is very nearly a finished product, but it is not so with the steel ingot. That is merely a form of material which for intelligent and economical operation of works it is necessary to weigh. Ingots are not an article of commerce to any extent, even between works. There is a large reduction in weight from the ingot to the finished rolled steel, due to the production of scale and of scrap, materials that are reclaimed, the one by the blast furnace, the other by the open-hearth furnace.

The production of finished rolled steel, on the other hand, represents substantially commercial steel, material that is bought and sold and put into use, with relatively little loss of weight. The statistics of rolled steel measure the material after its last hot rolling and after the necessary shearing. Thus sheet bars are not reported as rolled steel, the rolled material reported being black sheets, black plates for tinning and tin mill specialties. Pipe, on the other hand, is reported separately, while the skelp in included as finished rolled steel. Rods, again, are reported rather than billets or drawn wire.

The production of finished rolled steel in 1917 was 31,199,943 gross tons, against 32,380,389 tons in 1916. The rolled steel for 1917 plus the steel castings makes a total of 32,600,000 gross tons, which in a commercial sense might be considered the product of the steel industry, with some allowances for loss in wire drawing, pipe making, etc.

During the major portion of 1917 the United States was in the war and quite actively in it so far as preparation was concerned, while the industry was supplying much material for the Allies. Nevertheless, the analysis of total output of rolled steel, as rails, rods, plates, hoops, etc., diverged but little from the usual or normal distribution. Taking rolled iron and steel together, there having been 1,867,757 tons of iron rolled, there was a total of 33,067,700 tons. Of this, 3,110,000 tons was structural shapes, about the normal proportion, while 2,944,161 tons was rails, also not much out of line. The exceptionally heavy production of wire rods in 1916, however, was not repeated, wire rod production dropping from 3,518,746 tons in 1916 to 3,137,138 tons in 1917.

It may seem a trifle strange to those not addicted to statistics that there should be a larger tonnage of wire rods produced than of rails, but this has been the case for several years. Wire is ubiquitous, like the tin can, and indeed there was 1,512,146 tons of tin and terne plate made in 1917, or more than half the rail tonnage. The weight of steel in a mile of track laid in 100-pound rails is about equal to the weight of tin plate required to make 1,400,000 two-pound tin cans, but the tin can is more an article of individual consumption, and thus is necessarily very numerous.

An interesting item is that the production of sheared plates, ¼-inch and heavier, increased from 1,865,642 gross tons in 1916 to 2,461,938 tons in 1917, a gain of 596,296 tons. This was due to harder driving rather than to increased capacity, as most of the large plate mills lately built did not come in until 1918 and some of them indeed contributed but little even to that year's production.

Readers' Views and Comments

The Present Status of Oil Shales

To the Editor of Chemical & Metallurgical Engineering

SIR:—On page 25 of your Jan. 1 issue you publish an article headed "The Present Status of Oil Shales." Therein you say, "while the Scottish shale industry exists by virtue of the ammonia recovered as a by-product." Some years ago this statement would have been a true representation of the case, but it is true no longer, and your making it now may be the cause of much waste of capital. You use this statement as the basis of an argument, by which you endeavor to encourage the adoption in the States of what is known as the Scotch retort, but which I, in order that no misunderstanding may arise, have renamed the Scotch dual purpose retort.

I fear your study of the history of the oil shale industry in Scotland and of the evolution of the retort in Scotland and elsewhere has not been as thorough and complete as is desirable. The designing and construction of the Scotch dual purpose retort were the result of certain local conditions that have since very largely ceased to exist in Scotland, and which do not exist in any other locality where oil shales are found. The dual purpose retort was the result of these conditions, and credit is due the Scotch operators for perfecting the retort to suit the conditions they had then to meet. But for countries or for localities where those conditions are not present it would not be wise to advise the adoption of such an expensive retort, knowing that more expense would have to be incurred to adapt it to the local conditions existent.

Before any one gives advice, before any one decides what retort to operate, it would be well to understand what were the special conditions that evolved the Scotch dual purpose retort. The conditions were as follows: The sale price of crude oil was very low, away under to-day's prices and under the prices that existed immediately before the war. The sale price of sulphate of ammonia was very high, much higher than the price immediately before the war, or than the price will be in the future (see article in your journal of Dec. 15, page 827). The cost of manufacturing the sulphate of ammonia was very low, lower than it is to-day or than it will be in the future, with the exception possibly of a few localities. The shale to be retorted was low in yield of oil, but relatively high in yield of nitrogen. Money and machinery were low in cost.

What are the local conditions in the U. S. and in Canada? The sale price of oil is high, while the sale price of sulphate of ammonia will be very low, yet the cost of manufacturing the latter will generally be very high. The shale to be retorted is comparatively high in oil, but in the States generally low in nitrogen, while in Canada the nitrogen contents are sometimes very high, although deposits are found where the nitrogen contents are low. Money is dearer than in Scotland, and machinery, when erected, will cost much more. In fact nearly every condition to be faced on this continent is different from the conditions that existed in Scotland and which were responsible for the construction of the Scotch dual purpose retort.

Broadly, it may be claimed that while local conditions in Scotland at that time made the recovery of the nitrogen desirable, the local conditions existing in the States and Canada will make the recovery of the nitrogen generally unremunerative. This being the case, how can you or any one occupying a neutral position recommend or advocate the construction of the Scotch dual purpose retort, costly to construct and complicated to operate, a retort that costs more than double the price of the single purpose retort, while the accessories cost treble, upon all of which extra expenditures of capital there is likely to be no financial return?

The Scotch dual purpose retort is by no means a simple retort to operate, and if not carefully operated is liable to become damaged, entailing considerable loss of time and heavy expenditures for repairs. The requirements of the nitrogen-recovery half of the retort fight against the requirements of the oil-recovery half. The operator is ever "between the devil and the deep sea." If the heat is allowed to become lowered in the nitrogen-recovery half, the recovery of nitrogen is reduced; if the heat is kept up to the required temperature for good nitrogen recovery, the oil returns are reduced, and an excess of gas is produced. Owing to the constant variations in quality observed in all shale beds, or for other reasons, it is impossible so to construct the dual purpose retort that the requirements of the parts will never disagree.

Years ago was not the world told, "No man can serve two masters"? In the Scotch dual purpose retort this is what the operators have been trying to accomplish. That the efforts proved remunerative in Scotland, under the peculiar and special conditions then and there existing, is no justification for your advocacy of the adoption of this kind of retort, under conditions entirely different. Had you studied the history of the Scotch dual purpose retort, you would have learned that that retort has not been uniformly successful in its operation. You would have learned that when used for retorting shales of a quality different from that found in Scotland it proved a most disastrous failure. Did you never hear of the enormous amount of money lost in Australia through the failure of these dual purpose retorts? More money was lost than would have paid for all the experimental and "freak" retorts produced in the States and "then some," the construction of which is so deplored by Mr. Day.

I have a world of respect for Mr. David T. Day as a chemist, and also for the good work done by him on the oil shales of the United States, but this is not so much a problem for a chemist as for a business man with experience in operating chemical processes, and as such I have no hesitation in stating that the dual purpose retort, whether Scotch or American constructed, is not the retort required to-day to retort the majority of the shale found on this continent.

One of the experimental retorts mentioned by you is

the Wallace. Methinks I have read words of great commendation of this retort, made over the signature of David T. Day. Although I object to the intermittent method used of supplying the shale and of unloading the spent shale, especially when the shales being retorted are lean, I recognize that, if it be demonstrated by commercial operation that the oil contents of shale can be removed with only one hour of exposure to heat, this retort will cause a revolution in the designing and construction of retorts, a revolution that will give a black eye to all dual purpose retorts, be they Scotch or otherwise.

The retorting of shale will have to be considered on its own individual merits, that is, the retort and the working of the retort will have to be adapted to the quality of the shale to be retorted, and always with due regard to local climatic, industrial, financial and commercial conditions, the one aim being to secure for the men providing the money required for construction and operation the largest possible return upon their investment.

LOUIS SIMPSON.

Ottawa, Canada.

Instituto Cientifico Industrial del Salitre de Chile

To the Editor of Chemical & Metallurgical Engineering

Sir:—I am enclosing a copy of a circular letter which was distributed throughout Chile and resulted in the formation of the "Instituto Cientifico Industrial del Salitre de Chile." The idea has awakened very general interest in nitrate and allied circles which augurs well for the success of the project.

Knowing the general interest which is taken in Chilean nitrate in the United States, I think it might be useful to make public the knowledge of the awakening of the Chilean nitrate industry.

We shall be pleased to receive subscribers from the United States and hope that the steps taken here may find support among the scientific and technical societies of the United States in the many directions in which one society can assist another, and we trust that the interest which nitrate has aroused during the past years will lead to much research work in the U. S. A. which may help in one way and another to clear up many of the difficulties which beset the workers and the industry here.

BELISARIO DIAZ OSSA.

Santiago de Chile.

TRANSLATION OF SPANISH CIRCULAR LETTER

SANTIAGO, Oct. 12, 1918.

DEAR SIR:—The undersigned have the honor of inviting you to a meeting, which will take place on the 18th inst. at 2.30 in the rooms of the Sociedad de Fomento Fabril, Moneda 759, and which has for its object the formation of a scientific and industrial society in connection with the nitrate industry. You will deeply appreciate the advantages which such a society will confer not only on the country itself in its educational sense but also on the nitrate industry and those who are engaged in the study or direction of its different phases.

It is characteristic of the present period that there is a marked tendency to co-ordinate not only science and industry but also the workers who are occupied in the various branches of such scienece and industry, and there is little doubt that all those actually engaged in the various branches of the nitrate industry, in the technical studies relating to the process in use or in projection, or the actual manufacture and commerce of nitrate of soda will find, in a society of this kind, a new field for their activities, a place in which they can expound their ideas and discuss with their co-workers the different phases of the problems which are presented continually. Societies of this class, which aim at the reunion of men of science and of commerce, exist in almost all countries and for almost all industries, many of these latter being of less importance and of less vital interest than is the nitrate industry for this country.

The war has demonstrated the absolute indispensability of this class of society for the harmonious development of all industries. Governments have endeavored, even by compulsion, to form them where previously they did not exist, and have stimulated existing ones by the esteem with which they have regarded their activities. As an example, it will suffice to cite the case of France, where, in order to give the greatest development to French industries, both chemical and allied, the "Societé de Chimie Industrielle" was founded in 1917, whose valuable work is now beginning to make itself evident.

There exists in this country sufficient of the necessary elements for the formation of a similar technico-industrial society, but at the present time these factors are disunited and dispersed, and even without knowledge of one another, and our idea is to unite these for the general good and for the good of the industry and themselves.

One of the most important activities of the society will be the publication of a "Review" in which will appear not only original contributions on work done or being done of scientific as well as of commercial and technical interest, but criticisms of such contributions, discussions and abstracts of all work done in other countries in analogous industries, patents as well as original research.

This will bring about the necessary co-operation of the technical, scientific and commercial efforts which are being made individually to-day, and will form, at the same time, a bond of union between the nitrate industry and the chemical industry of other countries greatly to be desired.

We trust that this idea will meet with your views, and that you will lend us your assistance in bringing this society into useful existence.

J. BERKWOOD HOBSBAWN,
BELISARIO DIAZ OSSA,
J. L. GRIGIONI.

Classifying the Perkin Medalists

To the Editor of Chemical & Metallurgical Engineering

SIR:—If industrial chemistry is divided into the branches shown in the following table, the Perkin Medalists are distributed, according to their work, thus:

		Engineering Chemistry	Industrial Inorganic Chemistry	Metallurgical Chemistry	Industrial Organic Chemistry	Industrial Electro-Chemistry	Industrial Chemical Processes
1	1906				*Perkin*		
2	1908		Herreshoff			Herreshoff	*Herreshoff*
3	1909				*Behr*		
4	1910		Acheson			*Acheson*	
5	1911			Hall		*Hall*	
6	1912		*Frasch*		Frasch		
7	1913			*Gayley*			
8	1914				*Hyatt*		
9	1915					*Weston*	
10	1916				*Baekeland*	Baekeland	
11	1917				*Twitchell*		
12	1918			*Rossi*			
13	1919						*Cottrell*
Total		None	1	2	5	3	2
Worthy of mention, in addition		None	2	1	1	2	None

There is such inspiration in the record of these men that I should like to see a memorial volume published in which their lives and works would be available. The presentation proceedings might possibly form a starting point. To me this award is an outstanding thing in industrial chemistry today in the United States.

R. K. STRONG.

Department of Industrial Chemistry,
Oregon State Agricultural College,
Corvallis, Oregon.

Western Chemical and Metallurgical Field

Electric Pig Iron For British Columbia

STANSFIELD'S recently issued report on electric smelting of the iron ores of British Columbia is not a particularly encouraging document for the proponents of a west-coast iron industry. The author has been assured by competent engineers that accessible power could be developed for $10 per horsepower-year, but the present available surplus from the British Columbia Electric Railway Co. would cost $27.80! It may also be safely assumed that there is available an adequate supply of magnetite (50 to 55 per cent iron). Still, considering the fact that the entire consumption of pig iron in British Columbia is but 10 tons daily, while a plant large enough to give a moderate overhead would produce five times as much, the chance of marketing the output seems rather dubious. In the light of the recent experience of our own Western electro-alloy plants, the suggestion that ferromanganese, ferrochromium and ferrosilicon be produced when the demand for pig was slack does not strike a particularly responsive chord when considered as a means to increase the operating profit of the concern. Low-silicon pig for steel conversion could be made at any time, but its local utilization would require a highly specialized plant whose economical operation on such low tonnages is more than doubtful.

Electric shaft furnaces have been producing high-grade white iron in Sweden for many years, and this type is recommended for a permanent plant. For a cheaper, temporary installation the Electro-Metals pit furnace would probably suffice, Dr. Stansfield noting that the normal product could be made suitable for gray-iron castings by the addition of ferrosilicon. Magnetite low in copper, phosphorus and titanium is thought to be procurable, by water transport, at about $4 per ton. Magnetic concentration is mentioned as a possible method of increasing the tenor of the ore charge. Charcoal would be the reducing agent, obtained from the large quantities of mill-waste now available in the lumbering industry. By-products from Douglas fir are not sufficiently valuable to affect the production costs materially, but Dr. Stansfield thinks that by charring in large kilns, the labor charges may be reduced to a point where the coal can be laid down at about $6 per ton.

Summarizing, the cost per long ton of foundry iron is estimated as follows:

Iron ore, 2 net tons at $4	$ 8.00
Electric power, 0.45 hp.-yr. at $15	6.75
Charcoal, 0.4 net tons at $8	3.20
Electrodes, 15 lb. at 8c.	1.20
Repairs and maintenance	1.00
Labor	4.50
Management	2.00
Interest, 6 per cent on total capital, and depreciation, 10 per cent on cost of plant	2.60
Royalty to Electro-Metals Co.	0.50
Total	$29.75

At this price, electric furnace pig would be on a par with imported blast furnace pig, under the present tariff of about $5. A local iron and steel plant, using coke blast furnaces, is not to be expected for a number of years; eventually blast furnace pig will command the market, but electric furnace iron should always rule the market for high-grade material.

The final recommendations are:

(a) To develop one or more of the best iron ore deposits and to make complete tests of the ore.

(b) To reserve a suitable water power for future development.

(c) To establish a plant for the economic production of charcoal from mill waste.

(d) To investigate the new process of Trood and Darrah for the production of electric pig iron, and if this is found satisfactory to begin immediately to produce the pig iron, purchasing power for this purpose until the water power can be developed.

Collapse of Kelp Potash

A highly unsatisfactory situation has been suddenly brought about with respect to the Coast potash and kelp industry—particularly disappointing to those who were in hopes that the kelp industry could be perpetuated. Briefly, the armistice and its attendant events have caused the plants to close. There are still some exceptions, but apparently their operators have in mind the cessation of operations at an early date.

It has been evident for quite a while that the closing of some of the plants could hardly be postponed to the end of the war, since these were being operated by people not possessed of the requisite skill and experience to run a chemical factory. Some of the minor plants were started ill-advisedly, and even as "wildcats," and were later taken over by other people in order to save their investment. Under these circumstances it was scarcely to be expected that any great success as pioneers would follow their efforts. Their poor extraction of potash by crude and simple methods contrasted strongly against the very profitable manner in which this was done by others working under the same conditions, and they could scarcely be expected to produce the more refined products which kelp will yield and which must be depended upon to pay the way despite cheap potash.

The Hercules Powder Co.'s plant at San Diego,[1] the largest kelp concern in existence, ceased operations because its products were principally those which enter the war industries (all of which tumbled in price the moment the war terminated). Its potash, being a very high-grade chloride, was utilized in the preparation of potassium nitrate. Its acetone, of course, went into the manufacture of munitions. Prominent among other products were various aëroplane dopes. Other things it was manufacturing, such as acetic anhydride, the rare esters, and alginate bodies, while of importance and very great promise, were not sufficient to take the place of the decreased value of the other products. Had its operations continued for another year or two, this plant would have taken its place among the most important chemical factories in the country. But, of course, throughout the war period the greatest efforts were devoted to the production of war materials, the other researches being somewhat incidental and not carried far enough to permit the continuation of operations. The company had re-

[1]See METALLURGICAL & CHEMICAL ENGINEERING, Vol. 18, No. 11, p. 576.

cently inaugurated an advertising campaign to bring these various interesting and rare substances to the attention of the chemical public, but this had not gone far enough to yield results. Its scientific staff had done work which constitutes one of the most interesting chapters in American chemistry. Fortunately the data secured there are not going to be lost, but it is a misfortune that the promising young industry represented by the fermentation of kelp could not be added to our permanent national assets.

The Diamond Match Co. has caused its plant to be dismantled. Very little is known concerning the success of its operations, but evidently the management is confident it will now be able to obtain its requirements cheaper than it can produce them from kelp. This plant produced no by-products and did not get a quantitative extraction of potash from its rather expensive process.

It seems well accepted that it is not possible to produce potash from kelp commercially in normal times by any of the means so far tried, where no by-products are recovered. This statement possibly covers the reasons for the closing of the Lorned Manufacturing Co.'s plant at Summerland (whose operations were described in CHEMICAL & METALLURGICAL ENGINEERING for Sept. 26, 1918; Vol. 19, p. 450) and the Pacific Products Co. at Long Beach. These concerns have taken the position that the best time to close their plants is promptly upon the termination of a period of profitable operation and not to postpone it to a time when, through a sudden fall in the market price of potash or some accident to their plant, losses might be incurred which could not be recouped. This is entirely logical.

At Long Beach the Sea Products Co. still continues. This plant invested but a small original capital, and its profits by conservative and fortunate management have been great. It has paid for itself several times, and so its directors feel that they are justified in prolonging its operations. The Swift Fertilizer Co. at San Diego is still operating, and possibly will continue. Its plant has been a satisfactory potash producer, and it will possibly produce valuable by-products somewhat later.

Unfortunately, the experiments made at the Department of Agriculture's plant at Summerland have not been carried to that point where the Government's agents can say to the managers of the producing plants just what their costs and returns would be for the various by-products established as procurable and which offer definite promise of profitable extraction. Furthermore, to produce these substances would require a quantity of additional apparatus which would possibly double their present investment, and which of course they could hardly be expected to incur without a definite view of its ultimate recapture.

Gold Miners Present Program

Black Hills Mining Men's Association met at Deadwood, South Dakota, on Jan. 10, for a thorough discussion of the situation which confronts the gold producer in that district as well as in other parts of the world. Recognizing the real need of more gold, the continuing high cost of labor, machinery and supplies, the decreasing grade of ore in operating properties and the decadence of prospecting, the association passed resolutions prepared by H. W. SEAMAN, asking their State Legislature to memorialize Congress for relief along the following lines:

1. Remove restrictions upon the sale of bullion in domestic and foreign markets.
2. Allow liberal figures for plant depreciation and mine exhaustion.
3. Remove or refund special war taxes.
4. Exercise pressure toward more reasonable prices for machinery and supplies.
5. Extend aid to all endeavors to produce *new* gold.

Chloridizing Volatilization of Complex Ores

Metallic volatilization in complex ores in 100-lb. lots has been under experimentation for the past six months at the co-operative laboratory maintained by the Bureau of Mines and the University of Utah. A small-sized but rugged rotary kiln, 20 ft. long and 13 in. clear inside diameter is heated by oil burners. Ore is broken to 16 mesh, mixed with a proper amount of calcium or sodium chlorides, and fed to the upper or cool end of the kiln. Rotation of the furnace gradually works the mixture through, emerging approximately at 750 deg. C., this temperature varying somewhat for different ores. Seemingly oxides, carbonates and silicates of silver, gold, lead and copper are driven off as chlorides by this treatment, volatilization on silver ordinarily amounts to 75 per cent or better, while less than 10 per cent of the gold, lead and copper with all of the zinc remains in the residue. In furnacing, the coarser kernels of ore retain their original shape, while the fines roll up into small friable balls.

Fumes from the kiln are sucked through appropriate dust chambers by a fan, and then delivered to a Cottrell precipitator. Practically all of the coarser dust and considerable fume are collected in the chambers, while much of the finer fume is caught by electricity—an additional Cottrell treater is contemplated in order to better the final recovery. A certain degree of humidification may be necessary before complete clearance is effected, however. Dust and fume are melted with a limestone flux; by this means the metallic chlorides are reduced to metal, with the formation of a calcium-chloride slag, which, of course, may be pulverized and reused as a volatilizing reagent.

THOMAS VARLEY is the metallurgist now in charge of the station, although this experimentation has been in course of development for a long time under the personal direction of R. H. BRADFORD, professor of metallurgy at the university.

Passing of Goldfield Consolidated Mines Co.

After having produced in excess of $70,000,000 and paying dividends in excess of $28,000,000, Goldfield Consolidated Mines Co. has, within the last two years, extended its leasing policy until the small amount of remaining ground does not justify maintaining the staff and machinery necessary for its administration. A 5-yr. lease has therefore been given on the entire mining property, mill excepted, to an independent Goldfield Development Co. on a basis of royalty on ore produced, equaling 15 to 20 per cent of the proceeds from its sale, after deducting marketing charges.

New York Meeting of the American Institute of Mining Engineers

Annual Meeting Is Marked by Large Attendance and Excellent Program—Joint Sessions Held With Canadian Mining Institute—Special Attention Given to Industrial Relations—Change of Name and Election of Officers

THE first post-war meeting of the American Institute of Mining Engineers, held in New York City Feb. 17-20, showed in its attendance and general atmosphere the freedom and removal of restraint which the end of hostilities has brought to the engineering profession. There was a generous sprinkling of military uniforms at the various gatherings, worn by engineers who have not yet been mustered out of the service; but for the most part those members of the profession who had been giving so much of their time to war work had been relieved from public duties and were enjoying this opportunity for professional intercourse. More than 700 men registered during the meeting, giving the largest registration in the history of the Institute. The annual banquet was attended by more than 400, and all the technical sessions were well patronized by interested audiences.

Institute Changes Name and Elects Officers

At the annual business meeting it was announced that the proposed amendment to the constitution, changing the name of the Institute, had been carried, and that the name henceforth would be American Institute of Mining and Metallurgical Engineers. This alteration has been proposed for some time past in order to give recognition to the large membership of metallurgists in the organization. It is hoped also that the change will induce many more to join whose interests are primarily metallurgical rather than mining. This is particularly true of metallurgists engaged in the production of iron and steel.

Horace V. Winchell of Minneapolis was elected president for the ensuing year. Other officers elected were: Vice-presidents, Edwin Ludlow, A. R. Ledoux; directors, J. V. W. Reynders, George D. Barron, Charles F. Rand, Louis S. Cates, Stanley A. Easton.

In his annual report the secretary showed that the Institute membership increased by 666 during the year 1918, giving a total of 7158 on Dec. 31, 1918. The financial condition of the Institute is excellent, as shown by the audited treasurer's report of $8258 on hand.

Participation by Canadian Mining Institute

Tuesday, Feb. 18, was designated Canadian Mining Institute day, and was marked by joint discussions on the subjects of mine taxation, industrial relations, democracy and education, and uniform mining law for North America. President Dowling, Secretary Lamb and a delegation of members of the C. M. I. were in attendance and contributed to the discussions. The greatest interest attached to the paper on "Industry, Democracy and Education" delivered by Mr. C. V. Corless, director and manager of the Mond Nickel Co. His address was brilliant, forceful, logical and filled with choice epigrams. Based on the highest idealism, it nevertheless carried the greatest conviction, due to the earnestness of the speaker and the evident practicality of his ideas. Mr. Corless began his address with an inquiry into the causes underlying the unrest which exists throughout the world, and showed that they were not new, but were such as humanity had rebelled against for ages past—autocratic rule, not only political but

industrial as well. The prime cause of the great war he found in a conscious effort to perpetuate autocracy in political affairs. Similarly the cause of unrest in industry is not primarily low wages, long hours, no vacations and few holidays, but its essence is the individual's lack of interest in the end product of his toil. Having no chance to display his intelligence or imagination, he rebels against an external authority which he does not share.

Mr. Corless declared that political democracy and industrial autocracy cannot exist side by side, and stated that the great need of the world is democratic freedom and self-government in industry. The latter will be accomplished only by lifting the industrial problem out of the mire of sordid and selfish commercialism, and considering it from the enlightened viewpoint of right and justice in human relations. Slavery has been abolished as a political institution, and autocratic rule in industry must follow it to the scrap heap.

The Whitley scheme of industrial representation which is being tried in England met with Mr. Corless' approval as a large and necessary step forward toward industrial peace. "It is necessary to saturate our minds with the idea that the democratization of industry is fundamentally necessary," he said. Our industrial organizations have been turning out two products, one material and the other human, and we have been neglecting the latter to the point where it leaves the factory in worse condition than it entered. As a fundamental prerequisite to social democracy, Mr. Corless stated that the people must be educated to think economically, ethically and socially. We are at the beginning of a great transition period in industry, coincident with the end of the autocracy of capital. A new form of society cannot be created by changes in a political constitution, but it must find its inception in a quickening of the minds of the people in matters of justice and right. The discussion of those topics which were the subject of joint consideration in New York will be continued at the meetings of the Canadian Mining Institute in Montreal, March 5-7, 1919.

HORACE V. WINCHELL

Memorial Services

The life and work of Dr. Rossiter Worthington Raymond, past president, honorary member and secretary emeritus, were the subject of a memorial service during the session. Dr. Henry F. Drinker, president of Lehigh University, and Mr. T. A. Rickard, editor of the *Mining & Scientific Press*, spoke on the personal and professional attributes and attainments of Dr. Raymond. Both had enjoyed a long acquaintance and friendship with him and were able to speak appropriately. The Institute plans to issue a memorial volume containing tributes to the life and work of Dr. Raymond, as well as a history of the Institute which he had begun but not finished.

Services in memory of Institute members who lost their lives in the military service of their country were conducted by President Jennings. The Institute had about 845 members in the service, of whom, so far as is known, about 25 have died.

Social Features of the Meeting

The committee on arrangements promoted sociability among the visitors by various means. The noon luncheons served at headquarters were most effective in bringing together the members for a social hour. The smoker on Monday evening, with Mr. E. P. Mathewson as ringmaster, was a success from every point of view, contributing not only entertainment but also instruction. A new development in moving pictures was shown, by which it is possible to illustrate the internal action of mechanical devices, such as gas engines, machine drills, etc. Pictures on this order were used extensively during the war for the instruction of recruits, and should be quite as effective for industrial purposes. There was a large attendance of ladies at the meeting, and suitable entertainment was provided for them. Visits to Senator Clark's galleries, a theater party and trips to various points of interest in New York were arranged. The ladies also attended the noon luncheons at headquarters, and the lecture by Lieut. Pat O'Brien, who told of his capture and escape from Germany. About 350 members and guests of the Institute visited the shipyards of the Federal Shipbuilding Co., Kearny, N. J., to inspect the methods of fabricating steel ships. This company was organized by the U. S. Steel Corporation to assist the Government in its war program, but is now turning out ships for merchant trade. The yard has 12 ways and a fitting-out basin accommodating eight ships at once. The ships are 410 ft. long, 55 ft. beam and 27 ft. draft, with a cargo carrying capacity of 9600 tons. The visitors were shown through the shops and one of the ships, after which the company served luncheon at one of the dining rooms on the grounds. During the early part of 1918 experiments were under way at this yard for electric welding, with a view to building ships without rivets, but the sudden termination of hostilities brought the plans to an end.

Sessions on Industrial Organization

Two sessions were devoted to the problems of health, sanitation, housing, education, methods of employment, mental tests, Americanization, etc. Methods of employment of labor and the new change in industrial relations were discussed by Mr. H. M. Wilson, who said that the experience and knowledge of engineers impose on them the imperative duty of participating in the

solution of labor and capital problems. In the latter he saw four factors—labor, capital, the community and the managers. Most disagreements, he believed, resulted from the fact that both the employer and the employed were too engrossed in their own personal problems to sense each other's side of the question. In the Rockefeller plan of industrial representation and conference between managers and laborers, Mr. Wilson thought that a fair solution of the problem had been found. He also approved the Whitley scheme of the British.

The Use of Cripples in Industry was outlined by MR. JAMES P. MUNROE of the Federal Board for Vocational Training, which is assisting discharged soldiers who are handicapped by injury or disease. Through compensation by the War Risk Insurance Bureau and training by the Federal Board for Vocational Training, the discharged soldier is prepared for industry and is not allowed to remain a "cripple" in the old meaning of that term. This war work has shown the possibilities of retraining those who are disabled in industrial pursuits, and brings to the Federal Board a larger problem than it has in connection with disabled soldiers. Twenty thousand of the latter are to be retrained for industrial pursuits, but a larger number than this must be handled as a result of accident and carelessness in industry. In addition to this work the Federal Board has taken over the training of employment managers, begun by the War Industries Board, and plans also to give short courses in safety, etc., in schools where vocational training is being given.

Mental Factors in Industrial Organization and the part they play in labor problems were presented by MR. THOMAS T. READ. "The first requisites of success in industrial organization . . . are unity of purpose and co-ordinated activity." Failure to secure these requisites is caused in part by lack of opportunity for self-expression by the laborer in our modern industrial systems; in part by mental abnormalities in the individual which result in breaking down unity and co-ordination.

Mental Tests in Industry, the subject of one of the most interesting papers on the program, was dealt with by MR. ROBERT M. YERKES. The author gave a review of the mental tests adopted by the Army for grading enlisted men and officers as to intelligence, and showed that the gradings thus obtained were supported by classifications made later from everyday experience. He thought that these tests or similar ones should be of value in selecting men for industrial pursuits instead of leaving the choice to cut-and-try methods. The tests were prepared by a committee of the American Psychological Association and the National Research Council, and are applicable to men in the mass, say up to 500 at one time. The results are valuable for determining a man's probable limitations in various occupations, and for determining average intelligence standards for different kinds of work. In all the tests engineers stood at the head of the list. These tests have relation to intelligence only, and do not refer to temperament, moral qualities or effect of special training. So far as the Army was concerned, the tests showed that intelligence was the most important single factor in military success; and it is believed that good results can be obtained by their application in industry.

Fine Crushing in Ball-Mills was presented at some length and in mathematical form by MR. E. W. DAVIS. The author conducted his tests with Mesabi magnetite, sp.gr. 3.4 and hardness 7. The following deductions are drawn from more than 150 operating tests:

1. In every case an increase in the tonnage fed to the mill resulted in an increase in the efficiency.
2. In every test the limiting factor of the test was not the ball-mill, but some auxiliary apparatus, usually the classifier.
3. All tests point to the fact that the ball-mill is a machine of very large capacity, especially if it is provided with proper auxiliary apparatus.
4. Classifying and pulp-handling machines that will handle a circulating load of at least 500 per cent of the original feed should be provided.
5. Closed-circuit crushing is more desirable than open-circuit.
6. The real advantage in closed-circuit crushing lies in the fact that the maximum size of particle is nearer the average size of particle discharged from the circuit.
7. Two-stage crushing is more efficient than single-stage.
8. The real advantage in two-stage crushing lies in the fact that the ball charges can be adjusted more nearly to the required conditions.
9. Two-stage open-circuit crushing does not present this advantage, as the maximum-sized particle in both stages is more nearly the same.
10. The proper adjustment between size of balls and speed of mill can be secured by an examination of the classifier sands.
11. If the balls are large or the speed is high, the screen analysis of the classifier sands will be crowded at the finer sizes.
12. If the balls are small or the speed is low, the screen analysis of the classifier sands will be crowded at the coarser sizes.
13. From the data at hand, the indications are that the best efficiency is obtained when the screen analysis of the classifier sands shows a minimum of crowding at any size.
14. Balls no larger than necessary should be used, as this makes it possible to charge the mill with the greatest number of balls.
15. Balls smaller than can crush the larger particles of ore should not be kept in the mills, as they take up space, absorb power and do inefficient crushing.

Following are some of the conclusions as to operation of ball-mills:

1. By use of formulas the proper theoretical speed for the operation of the mill may be computed.
2. This speed is correct only when there is no slipping between the charge and the lining of the mill, and when the pulp is not so thick as to produce strong adhesion between the particles.
3. In actual practice it may be found that more effective crushing can be done at some other speed, but it would appear that the variations above or below this theoretical speed should be small.
7. The amount of crushing done depends upon the number of blows struck and the work done at each blow.
8. The number of blows struck can be increased by increasing the number and decreasing size of balls.
9. The work done at each blow can be increased by increasing the weight of the ball and by increasing the diameter of the mill.
10. From this it follows that mills of larger diameter should be charged with smaller balls and mills of smaller diameter with larger balls, when working on the same feed.
11. The proper operating speed of a ball-mill varies inversely as the square root of the diameter.
12. The proper operating speed of a ball-mill increases as the size of the ball load increases.
13. Due to interference between the balls, the volume of the charge should not be over 60 per cent of the volume of the mill.
14. Unless great care is exercised to prevent slippage, the volume of the ball charge should not be less than 20 per cent of the volume of the mill.
15. It would then seem that a ball charge that occupies between 30 and 50 per cent of the volume of the mill will give the most satisfactory results.
16. In an 8-ft. (2.4-m.) mill running at 22 r.p.m., with a 28,000-lb. (12,700-kg.) charge of 2-in. (50.8-mm.) balls, there will be an average of about 1,000,000 blows per minute; each of these blows will be equivalent to dropping a 2-in. ball 5 ft. (1.5-m.).

Conclusions on ball wear are summarized as follows:

1. In any mill, the rate at which the weight of any ball decreases is directly proportional to its weight.
2. In any mill, the rate at which the diameter of a ball decreases is directly proportional to its diameter.
3. In any mill, the rate at which the surface of any ball decreases is proportional to its surface.
4. Since the rate at which a ball loses weight varies as the work done upon it in the mill, it follows that the work done in wearing (or crushing) the ball varies as the weight of the ball. This is seen to be Kick's law.
5. It then appears that Kick's law holds true for the ball wear in a rotating mill.
6. The natural tendency is for the small balls to accumulate in the mill charge.
7. Since these small balls do very little crushing, and exclude ore and larger balls from the mill, if allowed to accumulate too long, a marked decrease in crushing efficiency will result.
8. Since the large ball is just as likely to strike the small pieces of ore and the small ball is just as likely to strike the large pieces of ore as the reverse, it would seem that all of the balls should be of a size to crush any of the particles of ore.
9. This means that the balls should be as nearly as possible of a uniform size.
10. Since spheres of uniform size provide the greatest amount of interstitial space, a mill charge composed of balls of uniform size will allow freer migration of the ore particles than a charge containing balls of different sizes.

Methods of Concentrating Manganese Ore were considered very broadly in a paper by MR. EDMUND NEWTON. The author gave no specific examples of concentration, but offered the following outline of methods that might be used, with due regard to the nature of the ore, size of deposit, location and other economic factors:

Simple Methods of Concentration:
- (*a*) Selective mining.
- (*b*) Hand picking.
- (*c*) Jigging.
- (*d*) Screening.
- (*e*) Log washing.
- (*f*) Water classification.
- (*g*) Roughing table treatment.
- (*h*) Slime table or vanner treatment.
- (*i*) Pneumatic separation.
- (*j*) Combination of two or more of the above.

Complex Methods:
- (*a*) Magnetic separation:
  1. Without preliminary thermal treatment.
  2. With preliminary thermal treatment.
- (*b*) Electrostatic separation.
- (*c*) Hydrometallurgical processes:
  1. Leaching with various acids. Precipitation by chemical substances.
  2. Leaching with various acids. Precipitation by electrolysis.
  3. Leaching with various acids. Evaporation of solution and heat treatment in rotary kiln.
- (*d*) Preliminary thermal processes:
  1. Drying, to remove hygroscopic moisture.
  2. Calcining, to remove carbon dioxide or combined water.
  3. Agglomerating fine concentrates to make them desirable for blast-furnace use.
  4. Volatilizing manganese at high temperatures in the presence of certain constituents which form readily volatile compounds.
  5. Direct reduction of oxides by carbon, under temperature control.
- (*e*) Miscellaneous processes:
  1. Flotation.
  2. Use of heavy solutions.

MORNING SESSION OF INSTITUTE OF METALS

Two sessions of the Institute of Metals Division occurred on the first day, largely attended by an enthusiastic group. Illustrating the wide range of interest, the feature of the morning was a discussion of the amorphous theory, and of the afternoon an appreciation of new methods in casting and melting manganese bronze. DR. ZAY JEFFRIES' paper entitled "Effect of Temperature, Deformation and Grain Size on the Mechanical Properties of Metals" is but one of a series of recent and important contributions to the knowledge of crystalline and amorphous phases of metal, and the mechanism of failure. The author cites experiments performed by himself and others showing diverse relations between strength, elongation and hardness as influenced by the rate of loading, temperature and past history, and then endeavors to explain many puzzling anomalies by a simple relation between cohesion and temperature of the metallic constituents. The subject is far too intricate for a short abstract, and is reserved for a later presentation at some length, especially since the amorphous theory as expounded by Jeffries is not universally accepted—as eminent an authority as Prof. Mathewson of Yale expressing his vigorous dissent from the idea of a truly amorphous phase, leaning rather toward a conception that a sub-crystalline superamorphous layer somewhat continuous with its surrounding metal is the cement which holds the crystalline aggregate together. Of interest to iron and steel metallurgists is the evidence drawn from Jeffries' curves between respectively, tensile strength, elongation or ductility and temperature. These show discontinuities at ranges between 30 and 300 deg. C., not entirely concordant, it is true, yet they present peculiarities easily explainable by the assumption of a low-temperature allotrope. This evidence may be sufficient to convince many metallographists who would like to postulate this phase.

VOLATILIZATION OF CUPROUS CHLORIDE ON MELTING COPPER CONTAINING CHLORINE

MESSRS. S. SKOWRONSKI and K. W. MCCOMAS, of the Raritan Copper Works, presented their results on the "Volatilization of Cuprous Chloride on Melting Copper Containing Chlorine." This is of much present importance, since any copper-leaching process giving chlorides either from the ore or solvent will electrolytically deposit cuprous chloride on the cathodes, which, if readily volatile, would represent large metal losses. It has long been known that in melting copper known to contain chlorine, the fumes evolved have been sufficient to interfere with the charging or to drive the workmen from the building, and that flue dust from furnaces melting copper with but traces of chlorine will analyze up to 15 per cent cuprous chloride. Experimentally, a small amount of copper containing various percentages of chlorides was melted and the volatilized copper chloride determined. The results, figured to a ratio of volatile copper to volatile chlorine, varied from 1.66 to 1.76 when melting under carbon dioxide, air, or furnace gases, as compared to a theoretical figure of 1.79 for total volatilization, and therefore it is considered that under present refinery practice all cuprous chloride in cathodes will be volatilized and lost to the bath.

A short paper on "Automatic Copper Plating" by MR. J. W. RICHARDS called for some comment. Especially MR. A. SILVERMAN reviewed the method of copper-coating steel by casting copper, brass or cupro-nickel around a red hot steel core, then rolling or drawing the composite bar. He exhibited samples of the finished

material, which has been adapted to a wide variety of uses.

Other contributions which were read by title were an important description of the results obtained in the "First Year of Leaching by the New Cornelia Copper Co.," by MESSRS. H. A. TOBELMANN and J. A. POTTER; "Die Castings and Their Application to the War Program," by MR. CHARLES PACK; "Two Instances of Mobility of Gold in Solid State," by MR. EDWARD KELLER; and "Notes on Electric-Furnace Problems," by MR. J. L. MCK. YARDLEY.

AFTERNOON SESSION OF INSTITUTE OF METALS

The feature paper of the Institute of Metals Division's afternoon program was MR. P. E. MCKINNEY'S paper on "Manganese Bronze." Mr. McKinney is metallurgist at the naval gun factory in Washington, and describes the methods he has used for over three years in the manufacture of highest grade manganese bronze castings by melting scrap materials in an open-hearth furnace. For instance, 250 lb. of a manganese hardener (scrap copper alloyed with ferromanganese) is placed in the bottom of the furnace; next is a ton of dross and skimmings from the cartridge-case plant and 400 lb. of zinc dross from the galvanizing plant. Seventy-five pounds of charcoal for reducing agent is next spread over the charge, and the balance of the heat added—principally yellow-brass turnings, zinc scrap, foundry scrap and skimmings. Common salt (80 lb.) is used to flux the dirt and collect oxides of iron and manganese. The reactions which form a bath of quiet metal from this mixture are similar to those in old-fashioned calamine-brass manufacture, while the small amounts of iron, tin and lead ordinarily added to virgin metal already exist in the waste materials used. Over a million pounds of castings per year have been made in this manner, ranging from small work to pieces of nearly ten tons, and while the lead content ordinarily is much above naval specifications, test bar results have been quite high, and the finished castings have withstood severe war service—which, doubtless, is the end and aim of a specification.

MR. J. L. JONES emphasized that the method could hardly be used with success in any but a large foundry, which has available a large supply of scrap of known origin and uniform analysis. Close chemical control is necessary, of course, and the speaker emphasized particularly the necessity of Mr. McKinney's practice of deoxidizing with aluminium and casting the original melt (figured to make a correct alloy) into ingots, which could then be analyzed and remelted with necessary corrective additions.

MANGANESE BRONZE MANUFACTURE

MR. G. H. CLAMER outlined interestingly the history of manganese bronze manufacture since "Parson's metal" was first made by the Cramps some twenty-five years ago. In particular he pointed out that this paper controverted the idea that a reverberatory is a bad place to make brasses, on the basis that it was hard to regulate the atmosphere and large oxidation losses in zinc and aluminium would therefore result. Especially the latter produces an infusible oxide which is hard to flux and is liable to segregate in the casting. The analyses quoted showed much higher lead than would be accepted from private manufacturers, and if the Government specification would be changed to correspond with the demonstrated facts, much waste and second grade metal could be utilized by all bronze-makers.

Many speakers contributed bits from their experiences. Especially was it emphasized that the results from test bars, whether cut from coupons, sink-heads, or hollow-milled from the body of the piece, depended to a preponderating extent upon molding practice; that is, of two of the same patttern, cast from the same heat at the same temperature, one, if properly gated and with correct risers and heads, would test perfectly, while the other, badly gated and with inadequate allowance for shrinkage, would test very low.

MESSRS. W. H. BASSETT and C. H. DAVIS, recognizing the impossibility of testing thin sheets in a Brinell machine, have worked out "A Comparison of Grain-size Measurements and Brinell Hardness of Cartridge Brass." Fig. 1 gives their results. At low annealing temperatures the grain size is influenced by the grain size of the previous anneal; but from 0.060 mm. upward the relation is unaffected by the history of the

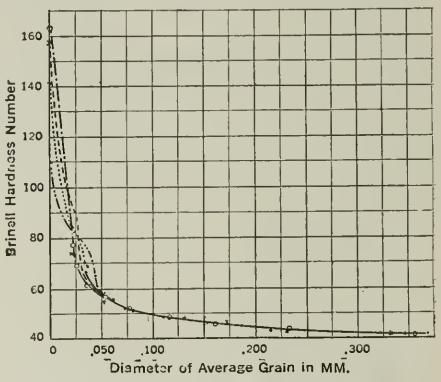


FIG. 1. BRINELL HARDNESS INDICATES GRAIN SIZE FOR ANY GIVEN BRASS IN THE ALPHA PHASE

piece. The grain size and the Brinell hardness change progressively with the percentage of copper in brasses, but their relation is a constant for each brass mixture in the alpha phase. Major White in commenting upon the fact that grain size measurements, as specified for sheets less than 0.1 in. thick, are slow and subject to the operator's personal equation, said the Bureau of Mines had worked up a "Baby Brinell" which was capable of testing thin sheets satisfactorily, and would prove valuable to quick, easy and adequate inspection of thin brasses.

Many of the metallurgists present had heard of colloids, and some had a dim conception of what the term was designed to express, but few had ever considered that such matters had definite application to their science until it was pointed out in a brief but very suggestive paper by MR. JEROME ALEXANDER on "Metals and Alloys From a Colloid-chemical Viewpoint." Particularly he urged thought toward development of methods to make sufficiently thin sections to be used under the ultramicroscope, with a view of attacking moot problems in the constitution of certain metallic phases.

Unusual occurrences abounded at this New York meeting. Not the least was the appearance of a feminine author, MISS LILIAN ERSKINE, of the New Jersey Labor Bureau, with a paper on "Standards for Brass and Bronze Foundries and Metal-finishing Processes." The paper dealt largely with the adequate provision of light, heat and air for the workers' health and efficient production in such plants—conditions not altogether easy to maintain at all times and seasons and therefore almost universally neglected. An appreciation of the money value of such comforts is spreading, however, and those who rebuild old or construct new foundries would do well to examine Miss Erskine's paper, or better, study the exhaustive material available at the New Jersey Bureau.

MORNING AND AFTERNOON IRON AND STEEL SESSIONS

Perhaps the most interest of the second day's sessions on metallurgical subjects was exhibited over the question of "Flakes," a defect in high grade steels which has recently caused much trouble. This subject is treated at length elsewhere in this issue and therefore it will not be repeated here.

MR. H. E. DOERR presented a short paper entitled "Does Forging Increase Specific Density of Steel?" describing experiments on several sound steel ingots in forged and unforged condition. Forging is shown to increase the density but very slightly, and thus controverts the popular conception, which would be true only for very spongy steel. MR. J. S. UNGER presented work indicating the opposite state of affairs to be true. As DR. H. M. HOWE pointed out, however, the specific gravity of steel is the result of various factors. As the carbon content and its heat treatment vary, the specific gravity changes owing to the different heaviness of cementite and the allotropes of iron. Gas cavities existing in cast metals may be closed in forging, increasing its weight, but on the other hand, forging has an almost irresistible tendency to open up a central pipe.

STATIC, DYNAMIC AND NOTCH TOUGHNESS

In "Static, Dynamic and Notch Toughness," the author, PROF. S. L. HOYT, called attention to the oftendisregarded fact that toughness is not synonymous with ductility, and that in general ordinary physical tests do not give an indication of the shock-resistant qualities of a piece of metal, especially if it is key-seated or used in the "notched" condition found at many places in modern machines. He therefore pleads for the adoption of a notched-bar impact test to determine a real factor of fitness for materials to be used in such ways. Various members contributed to the discussion, drawing attention to the extreme care to be exercised in order to get concordant results from shock tests, and to the need of an investigation to establish relationships between shock and fatigue tests. DR. MATHEWS emphasized particularly that internal notches, such as non-metallic inclusions, flakes or blowholes, are really more important in their effect on shock testing and actual service than are the external notches appearing by design.

MR. R. S. ARCHER gave the results of his work on the "Development of Grain Boundaries in Heat-treated Alloy Steels." It was found impossible to develop grain size in heat-treated chrome-nickel steels by ordinary etching agents. If, however, the steel be etched about ten minutes in a fresh solution of picric acid in ethyl alcohol, and the carbonaceous smudge polished off on moist broadcloth, the internal structure and any defects present were developed quite well, together with boundary "ghosts" of former crystals broken up into the extraordinarily fine crystals of hardened metal.

WATER-COOLED EQUIPMENT FOR OPEN-HEARTH STEEL FURNACES

Details of doors, frames, buckstays, port- and wall-coolers, valves and dampers were presented by MR. WILLIAM C. COFFIN, in "Water-cooled Equipment for Open-hearth Steel Furnaces." The author pointed out that the use of water-cooled equipment was, first, to hold the furnace to its lines, either in order to smelt correctly, or to relieve the brickwork from undue strains; second, to maintain the metal parts in question, and third, to increase the operators' comfort. On the other hand, the practice should not be elaborated to the point where the furnace would be cooled—in other words, the fuel burned in the furnace should refine metal and not melt refractories or heat cooling water. Practically, the desired result would be had in doors, for instance, by a one-course lining which fuses on its inner surface and burns back to a certain point where the heat radiating slowly outward is just sufficient to keep the hot portion solid. Ports are more difficult to protect since splashes of oxide flux the silica brick at temperatures as low as 1200 deg. C. At any rate, as pointed out by MR. UNGER, water cooling may be pushed to an extreme where the cost of fuel, maintenance, cooling water and the circulation of same is more than the savings in refractories, delays and metallurgical performance. As to materials of construction, welded steel plates are almost ideal, being uniform, thin and therefore conductive, strong and permanent. Cast iron, on the other hand, must be made with thick walls which are less conductive, therefore they warp out of shape and crack. Copper is somewhat more satisfactory, but it is expensive and difficult to cast in large masses.

MESSRS. J. S. MCDOWELL and R. M. HOWE presented a paper on "Basic Refractories for the Open Hearth," in which they gave results of laboratory tests on materials prepared from American dolomites and magnesites, largely used, as is well known, as substitutes for the imported material. While small-scale testing can never duplicate furnace conditions, the authors' work indicates that most satisfactory refractories may be made from Western magnesites low in lime, while non-slaking fettling may be made by coating granules of impure dolomite with basic open-hearth slag at high temperatures.

TWO NOVEL PROCESSES DESCRIBED

Two novel processes of manufacture were described by MR. J. E. JOHNSON, JR., and DR. J. W. RICHARDS, in their respective papers on "Davidson Process of Casting Formed Tools," and "Shimer Case-hardening Process." The first recorded the successful attempt to cast sound tools of alloy steels practically to shape which can be annealed, finished by light machine cuts, hardened and ground. Samples of intricate tools made by this cheap method were exhibited which comparative tests show to be equal to tools cut from rolled bars after

the usual method. Evidently successful tool-making by casting requires a thoroughly well-killed melt (effected by the use of a secret composition), producing no blow holes from dissolved gases or from green molds, fluid metal for making sharp castings, and a final metal satisfactory in physical properties. DR. RICHARDS' paper noted a successful war-time substitute which equals the case-carburizing action of the usual fused cyanide bath. MR. SHIMER found that a melt of easily fusible salts of commercial purity such as sodium, calcium and barium chloride will absorb calcined lump calcium cyanamide, with a lively evolution of gas, which effervescence continues as long as the bath has carburizing qualities. The rationale of the operation is as yet unknown.

A Metallographic Investigation of Transverse-Fissure Rails

MR. G. F. COMSTOCK in "A Metallographic Investigation of Transverse-fissure Rails, With Special Reference to High-phosphorus Streaks," attempted to harmonize somewhat the views of various rail-failure disputants, one group holding transverse fissures to be from fatigue, others insisting them to be from poor quality. The author carefully examined 24 fissured and 12 sound rails of known history, examining and classifying their sulphur prints, inclusions of alumina and of slag, and the amount of free cementite and ferrite exhibited, without finding any general relationship between such defects and the location or presence of transverse fissures. When etching polished steel sections taken normal to the fissure with Stead's cupric chloride reagent, the thin film of copper ordinarily deposited on normal metal was absent on segregated phosphorus streaks, in many cases the most pronounced of which passed through the fissure's nucleus, and fissured rails were pronouncedly more streaked than sound ones. DR. P. H. DUDLEY vigorously contended that transverse fissures were not fatigue failures, since normal wheel loads and track construction induce stresses far below the elastic limit, and result from abnormal metal only. Since but one break in 1585 is due to this cause, it is practically impossible to investigate the phenomenon in any way but by tracing the rail back to the mill. This done, it seems that 90 per cent are from direct-rolled rails. Reheating the blooms results in better rails either through allowing more time for the slow diffusion of phosphorus, as suggested by Comstock, or more probably by healing the fractured structure caused by the blooming mill, or by producing more uniform hot bed annealing and making necessary less gagging in the finishing department. As MR. G. M. DAVISON pointed out, a method should be devised to detect internal faults after the rail was in the track and before it caused a wreck. Electrical and magnetic tests had apparently not proved as satisfactory as anticipated. In any case, metallographists would have to demonstrate the undoubted existence of phosphorus in the streaks and to determine its rate of migration at reheating temperature before Mr. Comstock's proposal could be accepted, in view of the fact that phosphorus in modern open-hearth rails is but 0.03 per cent, while older bessemer rails, with four times as much, are practically free from transverse fissures.

The most notable feature of the session of the National Research Council was a clear analysis of the metallurgical practice necessary to produce sound, high grade alloy steels for munition purposes presented by DR. H. M. HOWE as an abstract of the unpublished "Report of Steel Ingot Committee."

His discussion applied only to the production of highest grades of steel containing perhaps 3.5 per cent of nickel, with or without chromium, from pure materials, and may be summarized by the phrase "refine hot and pour cool." The cold charge melts at a temperature of about 1440 deg. C. in approximately 6 hours after charging, whereafter the temperature is run up rapidly to the maximum which the furnace will stand—in the neighborhood of 1670 deg. C. This is to deoxidize the bath largely by its contained carbon, so that the products may escape from the melt and furnace as a gas. When the refining is completed the temperature is dropped very rapidly to stop the further oxidation of the carbon, so that the analyses returned to the furnaces some half-hour later may have some meaning. If these agree with the specification, ferromanganese is added to the bath essentially to add manganese to the steel—no more than 10 or 15 per cent of it should be oxidized at this stage, since the resulting slags are not entirely eliminated from the steel, causing inclusions and ghosts. About ten minutes afterward, when the temperature of the bath has dropped to the required point, the heat is tapped, cooling materially in the ladle, where it is held perhaps 20 minutes for it to reach its correct pouring temperature, which latter is of the greatest importance. Slow pouring is also essential: A rapid pour chills a solid skin of metal next the mold, the mold is later heated considerably by the interior hot metal, it expands, leaving the thin skin unsupported. This cracks from hydrostatic pressure and liquid iron flows from the inside. Slow pouring gives thicker walls at the bottom, capable of withstanding the interior pressure; it also reduces piping by supplying the pipe, growing from the bottom upward, with fresh metal. Pouring at too low a temperature must be avoided as well—a point somewhat below the liquidus is best where the metal is in the form of a thin emulsion, thin enough to form smooth and strong, thick walls against the mold but not mushy enough so that inclusions cannot be slagged off.

Distinction Made Between "Ladle Steel" and "Furnace Steel"

In the discussion of this and the two following papers a sharp distinction was made between "ladle steel" and "furnace steel"; one made with additions to open-hearth metal during tapping, while the latter denoted that all deoxidizers were charged in the furnace. DR. HOWE recognized the fact that tank-steel may readily be made economically by ladle addition, whereas cannon-steel certainly could not. Since metal is tapped below the liquidus, any solid ladle addition first chills a thick shell of solid steel about it, which later must be melted before diffusion can begin. MR. H. D. HIBBARD thought that for safety steel makers should adopt the rule to make only the best steel, but MR. F. N. SPELLER pointed out that this would hardly hold in all cases, since, for instance, certain welding steels cannot be produced by electric-furnace methods. In other words, impurities may at times be of value, and at other times

be of no harm—sash weights of melted tin cans are thoroughly good.

Two papers on manganese were read which would have been eagerly devoured six months ago, but to-day appear to be largely of historical interest. MR. P. H. ROYSTER'S study of the "Production of Ferromanganese in the Blast Furnace" presented a table of operating quantities gathered from eleven furnaces, wherefrom he draws information as to approved practice. Contrary to expectation, a high blast temperature does not appear to be as important as a basic slag in influencing the amount of manganese lost at the cinder notch. Leaving the alumina out of consideration, the author finds the ratio of bases to silica for good slags is usually 1.5, although it may reach the figure 2. Experience also bears out the common impression that it is easier to reduce losses by reducing the slag volume rather than the percentage of manganese in the slag—in other words, use only the purest ore, stone and coke obtainable. "Use of Manganese Alloys in Open-hearth Practice" was studied by MR. S. L. HOYT, in which he described substitutes for 80 per cent ferro. First, recarbonization and deoxidation have been effected simultaneously by use of a cupola-melted mixture of spiegel and pig, analyzing perhaps 6 per cent Mn and 4 per cent C. Second, use a high-manganese charge (scrap, ore and pig iron) and run the furnace with an 80 per cent manganese slag so that at the end the metal retains 0.30 per cent Mn. In such practice the phosphorus is early removed and slagged as calcium phosphate, and the heat finished at a high temperature. Third, silicospiegel can be easily made in the electric furnace from siliceous ores. Low-iron ores are available in the Rocky Mountains, but the high-iron ores so abundant in the Cayuna range are not so desirable, since a much greater quantity of the resulting spiegel is required to do the work. Information as to the use of this alloy is meager, although it is unquestionably suitable for acid casting practice. Three years' experience at one steel plant alternating silicomanganese with ferromanganese plus ferrosilicon shows the former to be somewhat more economical in alloy consumption, and to make for more uniform practice. It is doubtful, however, whether it could safely be used as a furnace addition in basic open-hearth.

EFFECT OF COLD-WORKING AND REST ON RESISTANCE OF STEEL TO FATIGUE UNDER REVERSED STRESS

MESSRS. H. F. MOORE and W. J. PUTNAM submitted a paper on "Effect of Cold-working and Rest on Resistance of Steel to Fatigue Under Reversed Stress." Their results show no marked benefit of a short period of rest on the fatigue strength of steel. Tests also indicate that an increase in strength of medium steel due to cold-working does not necessarily indicate increased resistance to fatigue, while the fatigue-strengths of cold-rolled and annealed steels apparently converge as lower stresses are used, even though the annealing temperature is of large importance. Most excellent moving microphotographs were exhibited, showing the development of slip bands under heavy alternating stresses, together with the progressive extension of incipient cracks. The methods and lenses for making these remarkable pictures were developed by Prof. A. G. ELDRIDGE of the University of Illinois.

Government's Policy in Sale of Surplus Supplies

REPRESENTATIVES of the War Department, the Navy Department and the Geological Survey have had a conference concerning the policies which they should follow. After this conference the Director of Sales, War Department, made the following statement:

1. The fundamental purpose of the conference was to determine, first, what each department of the Government had to sell.
   (a) Any department of the Government desiring material that any other department of the Government may have to dispose of should have an opportunity of obtaining it.
   (b) We should control our methods of selling in such a way as not to permit different departments of the Government to compete one against the other.
   (c) We must dispose of all surplus so as to disturb industrial conditions to the least possible degree.
2. It will first be necessary to give each bureau a record or statement of the surplus on hand.
   (a) We hope to have a more or less complete inventory by Feb. 15.
3. The War Department policy is:
   (a) To dispose of surplus materials to other bureaus of the War Department and other departments of the Government.
   (b) To sell to the contractor in whose possession the material is at a fair price.
   (c) To approach the producers or consumers of a particular material with the idea that they take it over at a fair price and dispose of it at a fair price.
   (d) To dispose of it through ordinary trade channels.
   (e) To put it on the open market.
4. Our general policy is to release small quantities in those instances where it is to the War Department's advantage to release to avoid the payment of storage charges or demurrage, and to accommodate those who desire to buy. In other words, our policy is one of slowly selling our commodities to disturb general market conditions as little as possible. We are not actuated by any desire to dump our surplus on the market without regard to the industry interested. Our general policy is to obtain as much from the sale of this surplus as we can. The trade should distinctly understand that it is not the policy of the Sales Department to sell property to any one for speculative purposes.

Conferences have been held relative to the disposition of surplus brass, copper and lead now on hand in the various bureaus of the War Department. It is expected that an agreement will be made with copper producers that will permit the Government to feed into the market its surplus of copper and brass in such a manner as to obtain fair prices for the Government without upsetting the market.

The situation with regard to lead is even more favorable, as the surplus amounts to only a few thousand tons, which is but a small proportion of a year's output. The same agreement will be made, however, and every precaution will be taken not to disturb the equilibrium of the market and at the same time to obtain the highest prices possible.

War Took All Candidates for Degree

There will be no candidates for the degree of Ph. D. in chemistry at Johns Hopkins University in June on account of the interruption in the work due to the war. However, a number will come up Feb. 22, 1920. The chemistry department of the university is rapidly recovering from the effects of the war and already twenty-one graduate students are devoting full time to chemistry.

Flakes in Alloy Steel

An Outline of Papers and Discussion of This Important Defect Presented at the New York Meeting of the American Institute of Mining Engineers—Divergent Views of Howe, Clayton, Rawdon, Foley and Laney

CONVINCING evidence of the commercial importance of metallographic science was exhibited at sessions of the American Institute of Mining Engineers, where veteran steel makers listened most carefully to technical papers on the origin and control of a relatively new defect known as "flakes." This subject is of much importance on account of the extremely large number of rejections in shops manufacturing nickel and nickel-chromium ordnance material. The control of the defects is most difficult and the conflicting evidence leads to the belief that in some instances at least their appearance in test bars was due to the method of testing and to the personal equation of the inspector. Two important papers on this subject, therefore, attracted much attention. First, C. Y. Clayton, F. B. Foley and F. B. Laney co-operated in presenting a contribution on "Flaky and Woody Fractures in Nickel-Steel Gun Forgings," and H. S. Rawdon presented somewhat conflicting views in his paper entitled "Microstructural Features of Flaky Steel." The whole matter was admirably summarized by Dr. H. M. Howe in his oral presentation of a report by the Steel Ingot Committee, National Research Council. In addition to these gentlemen, Messrs. Unger, Mathews, Stevenson, Speller and others participated in the general discussion.

Flakes are variously known as "flakes," "snow-flakes," "scabs," "lemon spots," "goose eggs," "silver streaks," and are often associated with a fibrous or woody structure in the fracture. Of course, the terminology is not yet precise. For instance, Mr. Rawdon illustrates silver streaks as shown in Fig. 1, and notes that each has in its center a tiny bit of greenish slag. Silver streaks are familiar to many as crystalline fractures due to presence of slags. The other defects are often associated with slag and some men view slag as their controlling cause. But flakes and fibrous structure have been found many times in the cleanest steel. Flakes are most common in chromium and nickel-chromium steels, which are notoriously quite tender under treatment, and in practice have been controlled and eliminated to an extent by well-regulated heating practice. They are supposed to be cracks within the steel itself, and as such would not be found in forged easily welded carbon steels, while a small percentage of nickel in the analysis reduces the weldability markedly. Evidence was cited that their presence is not controlled by the shape of the ingot, casting practice, size of ingot, reheating practice or per cent of reduction. Sometimes a plant would not be troubled with rejections on acount of flaky steel for some time after starting munition manufacture and then flakes would suddenly appear. For instance, Mr. Stevenson cited his own experience that no trouble was encountered during their early operations when they made steel from low-phosphorus scrap. Later as the croppings accumulated the charge was modified to consist of nickel steel scrap and low-phosphorus pig, whereupon flaking became very severe.

FIG. 1. CHROME-NICKEL STEEL WITH SILVER STREAKS IN FRACTURE —ACTUAL SIZE

Macroscopy and Microscopy

Flakes appear in a fracture as bright, silvery spots or areas surrounded by a normal granular field (Fig. 2). Especially is this the case when breaking a specimen which has a refined or hardened grain. It is apparently a spot of more massive or coarsely granular material than its surroundings, but under low-powered magnification there are no sparkling cleavage planes, but the corners and edges are rounded and smooth, suggesting surfaces of squeezed crystals. Clayton believes that the flake passes through the ferrite existing between the sorbitic grains, and partly through the grains themselves—following here the plates of ferrite, producing the Widmanstättian structure commonly observed, and very evident in Fig. 3. Rawdon, on the other hand, thinks that they are remains of the original crystalline faces formed on solidification, which have failed to unite, even during the kneading action of subsequent working.

Presence of the discontinuity known as a flake can be demonstrated after macroscopic etching. Thus, Fig. 4 gives their appearance in a polished transverse surface. Ordinary etching solutions attack the metal near the flake more quickly than elsewhere and leave tiny open cracks. Copper bearing solutions develop them—in fact such media always bring out non-homogeneity such as dendritic crystals or streaks. In a fracture the flakes oxidize less rapidly than the surrounding metal.

Finally, radiographs exhibit white lines which, on breaking the specimen, prove to mark the location of flakes; evidently the metal is more transparent to rays along these planes.

Microphotographs of defective steel always indicate a lack of grain refinement; sometimes this is very striking. Streaks or areas showing variations in grain size may be noted in less infected specimens. Clayton feels that the presence of flakes in exceptionally clean steel is evidence that they are not due to inclusions, while Rawdon apparently leans toward the idea that slag is materially responsible. He finds the filiform ends of coarse flakes to consist of extremely fine films of slag. This point is rather hard to determine, since, if flakes are intercrystalline defects, here, of course, would also be found any slag inclusions or segrega-

tions—an association which might indicate nothing as to the origin of the flakes. If the plane of flake intersects the polishing plane, it appears under high magnification as a black streak around the grain boundaries, thus following any ferrite mesh which exists. Microchemical work at the Bureau of Mines also indicates that the flake areas are higher in phosphorus and carbon than normal metal—differential action by copper-bearing etching reagents always exists along the borders of a flake, as already noted. Rawdon, while admitting the fact that the defect follows grain

FIG. 2. FINE GRANULAR FRACTURE SHOWING 59 PER CENT COARSE FLAKE × 3.5

boundaries, gives photographs such as Fig. 5, which show that a flake has no depth. Clayton and his associates lay much stress on the fact that they always find much evidence of overheating in defective material, such as Widmanstättian structure and spiny ferrite, drawing from this fact a basis of their theory as to their nature and proper control.

Physical Tests

The bulk of the work reported was performed on gun forgings containing 0.38 per cent carbon and 2.9 per cent nickel, with or without a small amount of chromium. When loading a defective test bar of this composition in tension, small cracks develop on the surface normal to the pull. This has led to the widespread idea that flakes are incipient cracks, a conclusion which is hard to reconcile to the unchanged elastic limit shown in the attached table.

TABLE I—PHYSICAL PROPERTIES OF GUN FORGING

	Minimum Specifications	Good Bars	Average of 182 Flaky Bars
Tensile strength	95,000	101,580	97,282
Elastic Limit	65,000	68,260	68,120
Elongation	18%	19.4%	11.6%
Reduction in area	30%	37.5%	20.5%

NOTE—The elongation and reduction in area of the flaky bars are extremely variable, depending upon extent of the defects at the breaking point.

Dr. Howe suggests that the constant elastic limit may be explained thus: Suppose a flake to be an internal area of small strength normal to the pull. The absolute value of the elastic limit would then be reduced according to the area of this reduced section. But as the flake has no depth, the elongation caused when this weak section passes its proportional limit is but a fraction of a thousandth of an inch. No contraction in area is possible in metal strongly supported on all sides, and therefore the extra stretch is not detectable to the extensometer, which naturally is not affected until the specimen gives over a considerable length.

Woody structure appearing in fractures is thought by Messrs. Clayton, Foley and Laney to be much different from flakes, and to emanate from the original dendrites in the ingot. Forging or rolling will elongate these crystals into parallel longitudinal lines giving very low transverse ductility. Such laminated structure is very persistent, annealing for days being required for its elimination. If this be a true explanation of woody structure it may evidently be cured by variable rotation of the ingot, which has been proved to reduce columnar solidification.

Are Flakes Formed During Reheating?

Clayton then proceeds to discuss the possible causes of flakes. First, they may be due to foreign inclusions (which possibility was disposed of above). Second, gas inclusions and cavities may be responsible—an attractive hypothesis which warrants much further investigation. Third, their association with ferrite may indicate them to be due to a local decarbonization resulting from churning in of oxide films formed on pouring. However, extremely few oxide inclusions were found. Fourth, the local segregation of non-ferrous elements to be expected at crystalline boundaries may be responsible for flakes. This is a contributing cause of low-melting areas, postulated by Clayton's hypothetical explanation. Fifth, the shape of the ingot and

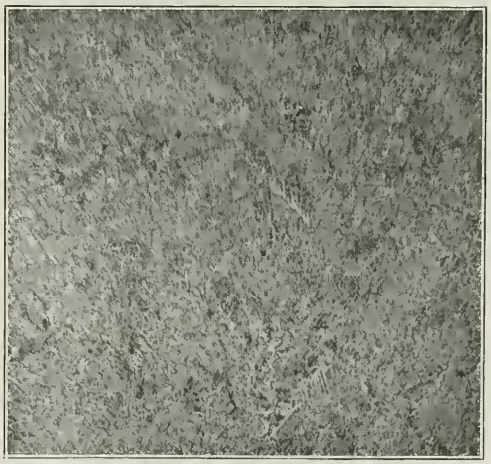


FIG. 3. MICROSTRUCTURE OF FIG. 2. FERRITE ROUGHLY OUTLINING PREVIOUSLY EXISTING COARSE NETWORK. × 260

the forging dies does not seem to have much influence. Sixth, flakes may be ruptures in the ingot caused by the differential coefficient of expansion in heretogeneous metal. This is approximately Rawdon's idea, he being ably seconded by Dr. Howe. Lastly, the theory which appeals most to Clayton and his associates is that flakes are due to overheating and non-uniform heat preparatory to forging.

Their experience with shop conditions leads them to believe that forging these special steels is ordinarily done at too high a temperature. For instance one

poorly designed heating furnace was run at 1370 deg. C. at the hot end, producing 70 per cent rejections in steel forged from this temperature, but much better results from the cooler portions of the hearth. If the billet starts too hot, it will be finished at too high a heat, giving a typically coarse grain always accompanied by Widmanstättian structure (Fig. 6). On the other hand with a light reduction under the hammer the temperature can be kept as low as 1040 deg. C., with a resulting structure shown in Fig. 7, and a total absence of Widmanstättian lines or other evidences of burning even under high magnification.

From this basis Clayton ascribes flakes to be ultimately due to slow diffusion of ferrite. In heating coarse-grained hypo-eutectoid steel the first transformation occurs at Ac_1 where pearlite areas revert to austenite of eutectoid composition. Alpha iron envelopes are absorbed at Ac_{y_2} but owing to slow diffusion the resulting austenite is heterogeneous even upon superheating, retaining a high-carbon core where previously was the center of the larger pearlite grains. Here is where fusion starts, and in forging these plastic spots are flattened out, persisting as films and boundaries to which excess ferrite is precipitated. Sorbitizing does not affect this film, and on breaking the specimen exhibits flakes. Thus the authors recommend that tender forgings be heated no higher than the solidus at eutectoid composition, or 1220 deg. C.

FIG. 4. FLAKES IN POLISHED DISK OF NICKEL-STEEL. ACTUAL SIZE

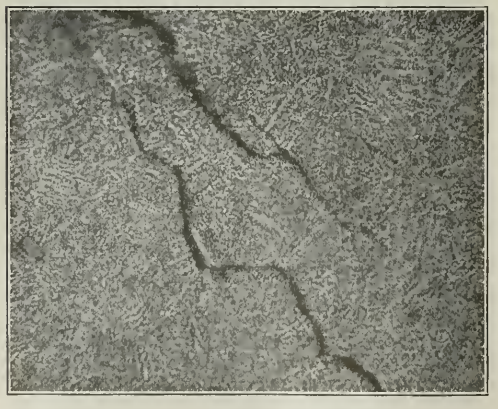


FIG. 5. FLAKES IN HEAT TREATED NICKEL-STEEL FORGING. × 500

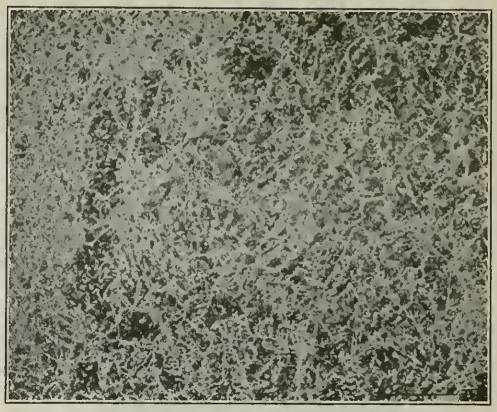


FIG. 6. IMPROPERLY FORGED BAR. × 6

Are Flakes Formed During Solidification?

Dr. H. M. Howe took issue with this theory, which in effect is that the previously solid metal developed, on pulling, a flake at segregated iron, phosphorus or sulphur spots. He supported the idea that the flake is the result of an old unwelded internal crack, deformed somewhat in forging, which opens up and becomes visible upon straining. Clayton's theory does not account for the fact that flakes are habitually ranged in a diagonal direction in square ingots, one-third the way from outside to center, and in a tangential direction in round or octagon ingots. Now if flakes were due to burning during reheating, they should occur in the outer portion of the ingot where it is hottest, assuming that the impurities which cause low-melting spots are not localized during solidification. Furthermore, flakes appear in steel whose heat treatment has never exceeded 900 deg. C.

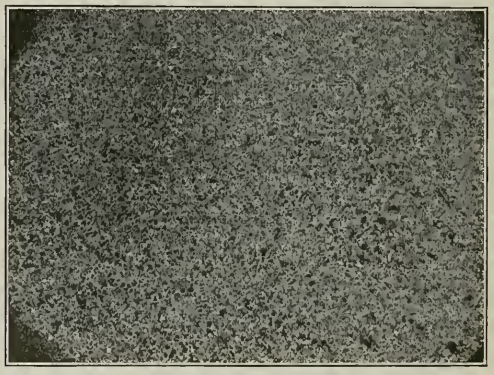


FIG. 7. PROPERLY FORGED BAR. × 6

Flakes are notoriously connected with tender steel, of the chromium, chromium-nickel, nickel, or chromium-

carbon varieties. Naturally, then, flaking disappeared in certain alloys as the nickel was reduced, and this composition was then found to be amply good for many uses. Again, killing the steel in the furnace increases its compactness, and therefore its tenderness; consequently this metallurgical practice caused more flakes. If such be the case, sound practice demands that this tender steel be humored and so cast that cooling stresses be not excessive; in other words use round molds, strip as soon as the walls are strong, and cool at an intermediate rate by burying in ashes. This lessens the number of flakes enormously, although it should increase the interdentritic segregation.

When Flaking Should Occur

There are three tender stages in the manufacture of a piece of metal, and flaking should occur at one of them. First in the mushy stage of early solidification, the outer walls of the ingot may crack and the fusible portion bleed. This should leave flakes with dendritic sides, as is shown in blow holes or pipes. But this is not their condition, and probably flakes are not formed so early. Second, at a blue heat, moderately below recalescence. Now the outer shell is contracting, while an inner lining just at the recalescent point expands suddenly, throwing large tension stresses into outer metal. The common occurrence one-third the way to the center also suggests that this is the most likely origin. A final tender stage in the history of a piece is when quenching the finished forging. Failure at this point, however, produces the well-known hardening cracks, which are flat breaks, with no white spots; fine crystalline because fine grained.

Hence Howe agrees with Rawdon in his contention that flakes originate in the ingots of tender alloy steels as intercrystalline shrinkage cracks, probably intensified by inclusions and segregations. They persist throughout forging, not being welded, and on straining, reappear with bright surfaces representing the deformed surface configuration of the original crystals. They can consequently be controlled by careful casting, soaking, reheating and heat-treating practice.

Prize Essay Contest in Industrial Economics

The National Industrial Conference Board announces a prize of $1000 for the best monograph on any one of the following subjects:

1. A practicable plan for representation of workers in determining conditions of work and for prevention of industrial disputes.
2. The major causes of unemployment and how to minimize them.
3. How can efficiency of workers be so increased as to make high wage rates economically practicable?
4. Should the State interfere in the determining of wage rates?
5. Should rates of wages be definitely based on the cost of living?
6. How can present systems of wage payments be so perfected and supplemented as to be most conducive to individual efficiency and to the contentment of workers?
7. The closed union shop versus the open shop; their social and economic value compared.
8. Should trade unions and employers' associations be made legally responsible?

Full details concerning the contest can be secured by addressing Magnus W. Alexander, managing director, 15 Beacon St., Boston, Mass.

Import and Export Statistics

The bureau of foreign and domestic commerce of the United States Department of Commerce announces the following import and export figures for the month of December, 1918.

IMPORTS OF TIN BARS, BLOCKS, PIGS, ETC., BY COUNTRIES AND DISTRCTS

Countries	Lb.	Value	Districts	Lb.	Value
England	179,662	$133,116	New York	768,973	$620,051
Mexico	748	578	Pittsburgh	392,000	299,706
British India	112,036	83,035	San Francisco	2,788,507	1,900,061
Straits Settlements	4,498,206	3,197,604	Washington	706,370	478,925
Dutch East Indies	114,689	89,931	Dakota	112,076	79,534
Kongkong	288,037	203,619	Chicago	726,468	522,053
Australia	693,685	490,666	Ohio	168,036	124,081
			St. Louis	224,633	174,138
Total	5,887,063	$4,198,549	Total	5,887,063	$4,198,549

EXPORTS OF TIN PLATE, TERNE PLATE AND TAGGERS TIN BY COUNTRIES

Countries	Lb.	Value	Countries	Lb.	Value
France	122,492	$8,284	Peru	135,000	$25,200
Italy	1,773,480	163,232	Uruguay	4,664,916	371,502
Canada	8,229,567	648,099	Venezuela	128,686	13,228
Panama	1,200	123	China	367,224	42,090
Mexico	99,687	11,042	British India	24,200	2,050
Newfoundland and Labrador	99,700	9,801	Dutch East Indies	37,021	2,484
Other British West Indies	460	64	Japan	507,556	61,675
Cuba	894,740	72,974	Philippine Islands	83,000	7,201
Argentina	13,219,016	1,151,934	British South Africa	116,798	5,973
Brazil	1,508,755	154,878			
Chile	617,299	98,735			
Paraguay	165,000	12,572	Total	32,795,797	$2,863,141

IMPORTS AND EXPORTS OF GLYCERINE

	Lb.	Value
IMPORTS:		
Total Imports	78,239	$28,237
EXPORTS:		
Countries		
Italy	253,242	124,724
England	195,888	113,615
British Honduras	10	10
Canada	218,706	126,762
Costa Rica	153	114
Guatemala	111	109
Honduras	9	13
Panama	2,283	1,426
Salvador	30	21
Mexico	1,112	840
Barbados	100	70
Jamaica	10	8

Countries	Lb.	Value
Trinidad and Tobago	50	32
Cuba	3,000	1,974
Dutch West Indies	100	74
French West Indies	12	10
Haiti	54	45
Dominican Republic	60	42
Bolivia	110	91
Chile	1,300	878
Peru	475	387
Venezuela	501	352
China	50	35
Dutch East Indies	105	73
Total	677,471	$371,705

UNITED STATES EXPORTS OF CAUSTIC SODA AND SODA ASH, BY COUNTRIES

	Caustic Soda		Soda Ash	
Countries	Lb.	Value	Lb.	Value
Denmark	800,000	$40,000	70,330	$3,125
Norway			2,025,734	74,099
Spain	1,334	92		
Sweden			1,711,115	53,363
Bermuda	347	25	560	29
Canada	1,165,722	58,541	6,334,049	165,630
Costa Rica	27,000	1,620	17,500	925
Guatemala	1,400	84	1,200	48
Honduras			50,900	2,001
Nicaragua	35,775	2,299	2,000	100
Panama	96,655	5,062	560	182
Salvador	41,040	2,362		
Mexico	1,562,567	85,397	246,481	7,616
Jamaica	2,500	125	336	7
Trinidad and Tobago	84	6	8,000	156
Other British West Indies	400	215	250	5
Cuba	523,362	22,885	1,047,405	14,015
Virgin Islands			600	20
Dutch West Indies	26	7		
French West Indies	1,025	67		
Dominican Republic	84,055	3,939		
Argentina	110,317	5,940	146,398	2,738
Bolivia	54,000	1,574	300	10
Brazil	779,891	43,487	468,910	15,108
Chile	232,925	13,135	110,768	3,507
Colombia	36,000	2,000	9,600	290
Ecuador	50	6		
Peru	604,329	30,243	25,350	832
Uruguay	3,864	173	45,640	569
Venezuela	191,883	10,249	145,100	4,715
China	527,580	35,355	273,890	8,250
Japanese China	149,350	8,512		
British India	62	22		
Dutch East Indies	251,600	16,770	207,600	9,869
Hongkong			15,000	750
Japan	1,202,371	71,947	7,805,813	275,284
Australia	39,600	2,200	1,161,538	48,028
New Zealand			12,000	580
Philippine Islands	207,245	10,001	1,000	63
Total	8,734,359	$474,340	21,945,927	$691,914

Linseed Production in Argentina

During the war enormous quantities of linseed were required to produce the oil for ship paint, camouflage material and rainproof equipment. Argentina, possessing the largest linseed area of any country, played an important part in supplying this demand. About 3,000,000 acres are devoted to linseed, while the corresponding area in the U. S. is only 2,000,000 acres.

The official estimate of the 1919 crop gives the total production as 705,000 tons, the exportable surplus being estimated at 679,000 tons, or about 29,000,000 bushels. During 1918, the United States received practically two-thirds of all the linseed exported from Argentina. On Dec. 5, 1918, the War Trade Board issued a ruling (W.T.B.R. 376) modifying the restrictions which had been placed upon the importation of linseed in July, 1918, to permit the licensing of imports from the River Plate districts (Argentina and Uruguay) of not to exceed 15,000 tons (635,000 bushels) for each of the months of January, February, March and April, 1919, allocation to be made by the War Trade Board.

The linseed requirements of the United States for the 1918-19 fiscal year were given as 26,000,000 bushels.[1] The supply from the American Northwest is given in the January official estimate as 14,657,000 bushels. This means that more than 11,000,000 bushels must be obtained from Canada, India and Argentina.

One of the most interesting developments in the attempt to increase the domestic utilization of the linseed crop has been the discovery that linseed straw is the most practical material for the production of grain bags. The shortage of warehouse space has made imperative the use of large numbers of bags for storing the wheat crops. A domestic source of supply has apparently been found in the 5,000,000 tons of linseed straw available annually, since experiments with the fiber indicate that it is suitable for the manufacture of bagging and binder twine also.

Important Meetings of Chemists and Electrochemists

The American Chemical Society will hold a "Victory Meeting" at Buffalo April 7 to 11. Tentative plans for the program include special consideration of the protection of American chemical industries and the necessary legislative action to secure such protection. Arrangements are being made for visits to plants of important Buffalo manufacturers and for a comprehensive view of the chemical industries of Buffalo and Niagara Falls. Headquarters will be at the Hotel Statler and sectional meetings will be held at the Technical High School.

The American Electrochemical Society will hold its annual meeting in New York April 3 to 5. The feature of this meeting will be a symposium on released information regarding war work. The censorship on scientific information which was enforced during the war has been largely raised and as a consequence it is anticipated that a great deal of valuable information can now be released. The sessions will be held in Rumford Hall, the Chemists' Club.

[1]Report of Linseed Oil Committee of the National Paint, Oil and Varnish Association at the convention held in Boston Dec. 2-4, 1918.

Industrial Use and Limitations of Respirators, Gas Masks and Oxygen Breathing Apparatus

DURING the last year the Bureau of Mines, Department of Interior, has received many inquiries regarding the use of Army gas masks in the industries for protection against poisonous and irritating gases. These inquiries show a general belief on the part of the public that this type of mask will protect the wearer under all conditions against any gas whatsoever, even in absolutely irrespirable air to the exclusion of the more cumbersome mine rescue breathing apparatus. This erroneous belief will no doubt be further confirmed by millions of discharged soldiers who have been trained in the use of the gas mask and have been taught that it gives them absolute protection against all gases used in warfare or likely to be used. These men will not realize that out in the open air of the battlefield the percentage of gas in the air can never be anywhere near as large as may occur in the confined spaces of a factory operation. A mask may afford complete protection under outdoor conditions and break down at once when used indoors where a gas container has burst and filled the room with a greater concentration of gas. It must also be remembered that the absorbents in the Army respirator, which filter out the poisonous gas, are specially designed for the gases used in warfare, and as a matter of fact do not protect against the more common industrial gases as, for example, illuminating, natural, producer and blast furnace gas.

The Army gas mask never should be used in mines, because of the uncertainty there is of the kinds and amounts of gases in the atmosphere and liability of insufficient ogygen to support life.

In view of these limitations of the Army gas mask, which, if not realized, will lead to serious accidents and fatalities, the Bureau of Mines is issuing this brief statement of the industrial use and limitations of the several dust respirators, gas masks and ogygen breathing apparatus.

Dust Respirators

Protection from dust and liquid mists is obtained by the use of a simple dust respirator, which removes these particles by means of a filter of moist sponge, cotton or wool pad, porous paper or even a very fine mesh metallic gauze. The respirator may enclose the mouth and nose only, or it may be combined with a face mask containing eye pieces if the eye must also be protected. The simple "pig snout" respirator containing a moist sponge has been on the market for years. It is highly uncomfortable to wear, rather insufficient for removing fine dust, and most workmen perfer to tie a large handkerchief over their nose and mouth. Some improvement has been made in recent years, but on the whole a really efficient and comfortable dust respirator that workmen will wear continuously is yet to be devised. On account of the urgent need of such a device for safeguarding the health of workmen in the mining and metallurgical industries, the Bureau of Mines has undertaken a study of dust respirators with a view to obtaining as satisfactory a model as possible.

The Army gas mask consists of a face piece of rubber and cloth fabric, containing eye pieces and connected by means of a flexible rubber tube to a canister containing charcoal and soda-lime for filtering out the poisonous gas from the inhaled air. The canister is supported in a knapsack slung from the neck.

The Army gas mask is by no means the unusual protective appliance that it is popularly believed. It does not afford universal protection against all gases, nor can it ever be used safely in low oxygen atmospheres. It furnishes no oxygen to the wearer and can only remove comparatively small percentages of poisonous gas from inhaled air, usually less than 1 or 2 per cent. Higher percentages will immediately penetrate the canister and "gas" the wearer. The standard Army gas mask will furnish protection against percentages not exceeding 2 per cent of the following gases in air: Sulphur dioxide, hydrogen sulphide, chlorine, carbon bisulphide, nitrogen peroxide, aniline vapor, benzyl bromide, benzyl chloride, chloracetone, chlorpicrin, hydrogen chloride, phosgene, sulphur chlorides, xylyl bromide, stannic chloride, titanium tetrachloride and silicon tetrachloride.

It will be seen from the above that the field of usefulness of the Army mask is confined to certain of the chemical industries, around smelters and roasters where sulphur fumes are given off and in the industries using chlorine and bleaching powder. The Army canister also contains cotton filter pads which remove irritating and poisonous dusts, which increases its usefulness around smelters where sulphur and arsenic fumes must be removed.

The Army mask furnishes no protection whatever against carbon monoxide. This is the poisonous constituent of blast furnace, producer and illuminating gases, and of mine gases after fires and explosions in coal mines. Carbon monoxide is also likely to be present in ordinary fire-fighting conditions met by fire departments. Moreover, in all of these cases there is likely to be a deficiency of oxygen. Therefore, for adequate protection against these conditions the oxygen breathing apparatus must be used, and reliance on the Army mask may be fatal.

Ammonia is another gas that will penetrate the standard Army canister. However, a special chemical may be placed in the Army canister which will adapt it for use around refrigerating plants.

Oxygen Breathing Apparatus

The self-contained oxygen breathing apparatus can never be displaced by the gas mask for use in atmospheres deficient in oxygen. Such atmospheres are encountered in mine rescue work, in gas mains, blast furnace stoves, gasoline tanks, etc. Aside from the lack of oxygen, carbon monoxide is also present, for protection against which the Army mask is useless.

The oxygen breathing apparatus must also be used instead of the Army gas mask wherever there are large quantities of irrespirable or poisonous gases, as for example, in entering a gasoline tank containing some residual liquid, or similar tanks, towers and other closed spaces. The concentration of vapors produced by volatile liquids in closed containers is too high to be entirely removed by gas mask absorbents. The only recourse in such cases is a self-contained appliance in which the wearer does not breathe any of the irrespirable atmosphere.

Importance of Taking Expert Advice

Owing to the many factors entering into the use of protective respiratory appliances, the importance of competent advice on the selection and use of such appliances cannot be overestimated. The fact that the Army and Navy used gas masks has been widely disseminated and its significance is likely to be misunderstood, especially by men who have had some training in their use. It also should be made known that both the Army and Navy used the oxygen breathing apparatus in its appropriate place.

In connection with the Bureau of Mines work of safeguarding the health of miners and workmen in the metallurgical industries, a general investigation of respirators, gas masks and breathing appliances is being undertaken at the Pittsburgh Experiment Station of the Bureau. This research will be conducted by experienced chemists and engineers who had charge of gas mask research in the Bureau's war gas investigations and subsequently in the Research Division of the Chemical Warfare Service, U. S. A.

Pittsburgh Experiment Station,
Bureau of Mines.

Summary of the Tin Situation by the Geological Survey

The tin situation in this country continues inactive and unsettled, caused mainly by the large stocks in the hands of the Government and of large consumers, and the restrictions on imports, except ore purchases by domestic smelters. In order to stabilize the erratic market which was so prevalent during the first half of 1918, announcement was made in September of the inter-Allied control. By this arrangement, buying in the primary markets was done by Government agencies, and no tin could be imported into the country except through the United States Steel Products Co. From the inter-Allied purchases there was allocated to the United States about 10,000 tons, at a price approximately 72½c. per pound f.o.b. Eastern points.

The signing of the armistice found the Steel Products Co. with practically the entire allocation on hand, besides large stocks in the hands of the principal consumers. Until these stocks are absorbed and restrictions removed from importation, the tin situation is likely to remain uncertain. How long it will take to absorb these stocks will depend mainly on the condition of business and the production of the domestic smelters, which are in an advantageous position, inasmuch as they can purchase their ores in an open market at considerably below the fixed price of tin in this country. They are in a position, therefore, to sell their product at a few cents under the fixed price, giving them the control of the market and at the same time insuring large profits.

It is estimated that the consumption of tin will be largely curtailed during 1919, and probably will not exceed 3500 tons per month. It is thought the requirements can be easily supplied by domestic smelters using foreign ores, supplemented by the stocks now on hand.

Concrete as a Chemical Engineering Material*

By Maximilian Toch

IT may truly be said that this is the age of concrete. What progress would our new factories have made after this country went into the war, when steel and iron were unobtainable, had it not been for the ability to use portland cement in its place? It is no criticism to say that portland cement concrete is an unfinished material when used in the erection of chemical works. No floor in any factory will last very long made of portland cement and sand, unless it is treated in some manner. I have seen instances where the concrete foundations of vinegar tanks were decomposed until they resembled a material like cheese, owing to the solvent action of acetic acid. I have seen foundations of motors and machinery where the oil drippings disintegrated concrete in a relatively short period. I could cite many more cases, but these will suffice. There are a great many materials which preserve portland cement construction against acids, alkalis, oil and saline solutions, and there is no one material which may be regarded as a panacea for all the defects of concrete. When the defects of concrete are mentioned I must again impress upon you that I am not criticising the material; but a concrete sidewalk is about the only cement construction of any magnitude that I can recall which needs no treatment to make it waterproof, wearproof and weatherproof.

Defects of Concrete Construction

Take the case of a concrete floor in a room where there is delicate machinery. In a short time the particles of sand and broken stone which form the composite of the concrete became loosened, float around in the air and lodge on the contact points of this delicate machinery. Take the case of foundations in chemical works, where acids and alkalis drip on the foundations. Take the case of concrete foundations of factory buildings on a waterfront, where niter cake and sludge acids are discharged in the stream, and you will soon erode the concrete foundations. All this is due to a very simple chemical problem. Portland cement has been described so often that I do not need to go into its chemical composition other than to say that when it is mixed with water it generates lime and the lime forms a glutinant material which binds the particles together. This same condition is identical in all mortars, and the common, ordinary lime mortar of building material, while it contains a much greater amount of lime than portland cement, is weaker in every respect than portland cement itself. Lime is slightly soluble in plain water and is relatively more soluble in salt water. This accounts for the disintegration of portland cement at the seashore. Any acid, no matter how weak, forms a chemical combination with lime; when the lime is attacked in portland cement the structure crumbles.

There are a large number of methods used for the protection and preservation of portland cement; and, as I have said before, there is no single method applicable in every case. Our Government and every other Government have had an enormous amount of trouble in building dry docks which would withstand sea water, even though some of these dry docks were faced with granite or other building stones, because the building stones must be cemented together with a mortar containing lime in some form. A very interesting case developed in one of the large dry docks in New York Harbor, where the sea walls were waterproofed with an integral material but where the bottom was not waterproofed, and after a lapse of five years the solvent action of the salt water attacked the bottom, but left the sides untouched. But the greatest problem of all is the construction of foundations, vats and storage buildings for chemical materials which should be proof against acids and alkalis under normal conditions. Up to within two years ago no one ever thought of building storage warehouses of concrete for the storing of large quantities of niter cake. This material, as you know, is an acid sulphate of sodium containing as high as 30 per cent. of free sulphuric acid, and yet it has been possible to build successfully such a storage building which would house niter cake and not attack the walls and floors made of concrete. In a case like this, it is necessary to use two methods—one, an integral method, and in addition to this, a surface coating which will be acidproof.

Concrete Tanks for Storage of Oil

The great scarcity of boiler plates for the building of large tanks forced our own Government to build tanks for the storage of fuel oil, of concrete; and, as there are two kinds of fuel oil—the very heavy Maltha, of the West Coast, and the thinner type of Pennsylvania and Ohio—it soon becomes obvious that the Maltha or Western type could be stored in any kind of a pit made of any material, but the Eastern oil would soon destroy the crystalline structure of portland cement and leak through. So it became essential to find methods of making concrete oilproof, and in this again the integral plus the surface coating method are essential.

To use a very homely comparison, and one that is somewhat graphic, I must frankly state that unless the engineers' specifications are strictly carried out, failure will inevitably result and no material should be blamed for a lack of supervision. To write a specification for concrete and chemical engineering construction is not an easy matter, and unless the inspector is intelligent and watchful, failure may result. I always think, in this connection, of the case of the man who went into a restaurant and called the waiter, and explained to him the kind of a steak that he wanted. He insisted that the steak should be an inch and a half thick and six or seven inches long, and it should be grilled over a coke fire for forty-five minutes at a distance of one foot from the fire; that after it was grilled it should be smothered with mushrooms and onions and then allowed to seep for ten minutes and placed on a hot plate and served to him. The waiter, after having carefully listened to these orders, walks over to the kitchen and yells "One steak." This is a very fair example of how many specifications are carried out and how engineering materials are blamed for the lack of carrying out the orders carefully.

*Address delivered before the American Institute of Chemical Engineers, Chicago, Jan. 16, 1919.

It is not my purpose to give any specifications for the various types of waterproof and chemicalproof materials now on the market for the preservation of portland cement concrete; but suffice it to say that there are not very many materials on the market which are completely meritorious, and the negative attitude in times gone by of the Bureau of Standards is to my mind largely due to the fact that several materials have been exploited which have been without merit. In fact, unless a man is scientifically trained and knows the reactions that may take place when various materials are subsequently stored or come in contact with concrete, he cannot devise a material which shall fulfill the purpose, but fortunately, as these materials are found out and found wanting, they from time to time disappear from the market, but in the meantime they harm directly and indirectly those compounds which have shown and proven their efficacy. I have a case in mind where one of the foremost architects in the United States has condemned all materials on account of failures which he has seen made with materials which should not have been used.

Types of Waterproofing Used in Chemical Industries

The following, in a general way, are the types of waterproofing used in the chemical industries:

First—The integral type, which is used in the form of a dry powder, and the action is to densify the concrete, give it colloidal properties and to lubricate the mass while pouring. There are a large number of paste aqueous materials on the market, some of which are a kind of soap. Generally speaking, these soaps are to be avoided.

Second—The next type well known is the varnish type, which depends for its reaction on acid resins and has proved itself waterproof, oilproof and wearproof.

Third—The third type is the fluo-silicate type, which in conjunction with the acid resin type or the bituminous coating type, where a proper bond can be effected, has given most excellent results.

There are, of course, modifications of these types, and I have in mind the building of the first storage building for niter cake large enough to hold a thousand tons, in which the concrete, after two years, has not shown the slightest disintegration. Another modification of this type is used for the building of concrete foundations along waterfronts where the water is decidedly acid and it is quite obvious that unless the concrete is properly treated the solvent action of acid water would erode and dissolve away the concrete in a short time, and yet under proper treatment such foundations have stood up without showing the slightest sign of decay or disintegration, and the manufacturers are all aware of the fact that concrete may be constructed which is proof against acid fumes, and a number of these buildings are all in successful operation.

We must bear in mind that civilization is the great destroyer of our building materials. In the balmy air of southern Italy, where temperature changes are not very great and where the people still burn wood, and very little of that, and that only for domestic purposes, the masonry construction of the Roman Aqueduct has stood for two thousand years without disintegration. The same is true of the masonry construction of Egypt, yet we know that our obelisk, after having stood for twenty centuries in Egypt, began to disintegrate after it was erected in Central Park in New York, due first, to the climatic changes, and secondly, to the sulphuric acid in the air. I had occasion to examine most minutely the Tomb of Perneb after it arrived and was set up at the Metropolitan Museum of Art in New York. This tomb was built 4500 years ago, and the stones were in perfect condition when they arrived, but the atmosphere in New York soon began to produce an excrescence, due entirely to the foreign substances in our atmosphere. The same is true of the monumental buildings of London, where, as long as there were no factories, the great buildings showed no signs of decay, but when London began to burn soft coal and belched sulphurous and sulphuric acid into the air, the building stone and cement construction immediately showed signs of decay and deterioration. This condition is of course amplified by the ordinary fumes in a chemical factory itself, and it is very fortunate that through modern methods of skillful investigation portland cement can be made to resist these conditions. Railway engineers are recognizing this all over the country, and where locomotive blasts belch forth their fumes against concrete bridge arches, the arches are treated so that they will withstand the onslaught of chemical vapors.

Methods of Protection

Briefly summed up, the methods for the protection of concrete against erosion, chemical action, disintegration and decomposition are as follows:

First—The well-known membrane method, which consists, usually, of applying tar, asphalt or other bituminous materials, in conjunction with a membrane such as felt, burlap or textile fabric of any kind;

Second—The brush application on the exterior of a concrete construction of a hydrocarbon material which is neutral;

Third—The brush application of an acid resin which combines with the lime of the concrete and forms an integral material on the surface only;

Fourth—The addition of a dry powder not to exceed 2 per cent, to densify concrete and to make it waterproof;

Fifth—The addition of an integral powder to the concrete, to make it acidproof and alkaliproof;

Sixth—The application of a brush coating or spray of a silicofluoride, which precipitates silica into the interstices or pores of the concrete and makes it proof against oil and water;

Seventh—Coating the concrete structure with two solutions which interact and precipitate and form an insoluble residue which prevents penetration of chemical compounds.

This, in a general way, is the practice of the present day, and sometimes two or more methods are used where the concrete is subjected to extraordinary conditions, but sufficient work has been done on this subject to enable chemical engineers to state with a considerable degree of assurance that concrete, which ten years ago was regarded as unfit as a building material in the chemical industry, can to-day be so manipulated that it has taken its place as one of the best, if not the cheapest, and most enduring material in chemical engineering.

Milling Calculations

A Compilation of Formulas Useful in Determining Extraction of Processes, Efficiency of Machines, Density of Solids, Solutions and Pulps—Notes on Methods of Testing and Microscopic Examination

By ROBERT S. LEWIS*

IN ORDER to exercise proper control over the operation of milling plants it is necessary to make frequent and regular calculations of mill performance. The extraction made by the plant, by the individual machine or group of machines, and the tonnage treated are the items that most commonly require determination, and these are computed by means of weights and assays. Efficient and economic operation demands that concentrating machines be operated at full capacity and with a uniform rate of feed, but such conditions are seldom if ever attained in practice. As soon as a mill goes into operation the usual tendency is to crowd through it as large a tonnage as possible. Many a plant is handling an overload of from 50 to 100 per cent, if the capacity for which the mill was originally designed is taken as a basis of calculation. It is impossible to prevent choke-ups in pipes and launders, belts jumping off, or the breaking of machine parts. These result in sudden stoppages of feed, and, even though promptly remedied, prevent the maintenance of smooth operating conditions.

Computation of Extraction

Skilled as some operators become in judging the performance of a machine, the actual work that it is doing cannot be learned without making tests. For plants using straight mechanical concentration, the calculation of extraction deals with only three quantities: feed or heading, tailing and concentrate. Where the weights and assays of these items are known, the calculation of extraction is quite simple. For plants using a more complicated process, such as concentration followed by the cyaniding of sands and slimes, the computation of extraction becomes longer. The difficulty of correctly sampling certain mill feeds, such as those containing native gold or native silver, is often urged as a sufficient reason for using the method where extraction is based upon the metal recovered and the loss in the tailing. Instead of using the formula

$$\text{Extraction} = \frac{\text{Metal in concentrate}}{\text{Metal in ore}}$$

it is considered that

$$\text{Extraction} = \frac{\text{Metal in concentrate}}{\text{Metal in concentrate} + \text{loss in tailing}}$$

This latter method may be satisfactory from the viewpoint that the operator is concerned not so much with what is in the ore as with what he recovers and what he loses. However, such a calculation does not show the losses that may take place in the various stages of operation, for example, the wasting of valuable solutions and the loss by dusting or through fume and smoke in smelting plants. All quantity estimates are based on dry ore, yet the latter formula would not indicate that a serious error in moisture determination was being made.

Consider the case of a copper concentrator handling 10,000 tons of ore per day. This is reported as dry weight, but suppose an error in moisture determination has been made so that this weight really contains 0.5 per cent of water. Then 50 tons of water is daily reported as ore. This amounts to 1,500 tons at the end of a month and if the ore assays 2 per cent copper, the discrepancy between the amount of copper calculated as coming to the mill and that actually contained in the ore is 60,000 lb. per month. This copper has apparently been lost in the mill, since the copper actually in the concentrate together with that lost in the tailing fails to check the copper in the feed by this amount.

Formulas Disregarding Middlings

It is not convenient or always possible to segregate and weigh the concentrate produced each day, but its weight can be calculated, as will be shown below.

Let H = weight of feed. (Generally in dry tons of 2000 lb.)
T = weight of tailing.
C = weight of concentrate.
h = assay of feed.
t = assay of tailing.
c = assay of concentrate.

As the whole is equal to the sum of its parts, we may write

$Hh = Tt + Cc$ and $H = T + C$. Eliminating T,
$Hh = t\,(H - C) + Cc$ or
$H\,(h - t) = C\,(c - t)$, whence

$$(1) \qquad \frac{H}{C} = \frac{c - t}{h - t} = R$$

R is called the ratio of concentration and signifies the number of tons of feed required to yield one ton of concentrate. When this figure has been determined for an ore, it is a simple matter to calculate how much concentrate will be obtained from a given tonnage of ore or what tonnage of ore should be put through the mill to yield a desired weight of concentrate. Thus $H = CR$, or $C = H/R$.

The extraction E is the percentage of total mineral in the ore that is obtained in the concentrate. Obviously $E = Cc/Hh$, but this has the disadvantage of requiring weights as well as assays for its solution. By combining this formula with formula (1) for the ratio of concentration we may write

$$(2) \qquad E = \frac{Cc}{Hh} = \frac{c}{Rh} = \frac{c(h - t)}{h(c - t)}$$

In this formula all weights are eliminated.

*Professor of mining, University of Utah.

Example: The assays from a copper concentrator are as follows:

Feed	1.6 per cent Cu.
Tailing	0.6 per cent Cu.
Concentrate	16.0 per cent Cu.

Then $E = \frac{16(1.6 - 0.6)}{1.6(16 - 0.6)} = 0.65$, or the extraction is 65 per cent.

When the weights of the feed and tailing or the concentrate and tailing are known, we may write

$$(3) \qquad E = \frac{Cc}{Cc + Tt} = \frac{Hh - Tt}{Hh}$$

Formulas Involving Middlings

In case a middling product is made and must be taken into account, the formulas become more complicated and it is necessary to use both weights and assays[1].

Let M = weight of middling and m = its assay, then, using the same notation as before,

$$(4) \quad E = \frac{Cc}{Hh} = \frac{Cc}{Tt + Cc + Mm} = \frac{Cc(h - t)}{hC(c - t) + Mh(m - t)}$$

$$(5) \quad T = \frac{C(c - h) + M(m - h)}{(h - t)}$$

$$(6) \quad H = \frac{C(c - t) + M(m - t)}{(h - t)}$$

In some cases the interpretation of small scale gravity concentration and flotation tests is rendered ambiguous by a middling product, which would be eliminated in regular operation by being returned to the head of the machine[2]. The value of the clean concentrate and tailing produced would not be affected by the return of this middling. Such an assumption seems justifiable on the ground that the middling is of the same materials as the ore, being merely a mixture of the same constituents found separately in the concentrate and tailing.

An Illustration

Suppose a 10-lb. sample of gold ore assaying 0.895 oz. is concentrated with the following results:

1.15 lb.	middling assaying	0.35 oz.
1.25 lb.	concentrate assaying	6.53 oz.
7.60 lb.	tailing assaying	0.055 oz.

It is desired to calculate the weights of the products and the extraction with the middling eliminated. If R by formula (1) gives the tons of ore required to make 1 ton of concentrate, 1/R is the fraction of a ton of concentrate made from one ton of ore. Inverting formula (1) and substituting the above assays gives

$$\frac{1}{R} = \frac{0.895 - 0.055}{6.53 - 0.055} = \frac{0.840}{6.475} = 0.1297$$

As the assays of the concentrate and tailing remain the same, the total weight of concentrate produced would be $10 \times 0.1297 = 1.3$ lb., and of the tailing $10 - 1.3 = 8.7$ lb. We now have for a sample of 10 lb. of assay 0.895 oz., a concentrate of 1.3 lb., assay 6.53 oz., and a tailing of 8.7 lb., assay 0.055 oz. The extraction can now be calculated by formula (2).

Consider the following flotation test: 500 g. of ore is treated in a test machine for fifteen minutes, the products being a final tailing and a rough concentrate. This concentrate is re-run, giving a finished concentrate and a middling, which is too valuable to run to waste. In practice the middling is returned to the head machine. The data from the test are tabulated below:

	Weight Grams	Assay Per Cent Pb
Feed or heads	500	5 7
Concentrate	31 5	41 0
Tailing	470 0	2 1
Middling	48 5	13 94

From (2) the extraction is $\frac{41(5.7 - 2.1)}{5.7(41 - 2.1)} = 0.666$ = 66.6 per cent.

The relative weight of concentrate, the middling being eliminated, is found from formula (1), inverted, as $\frac{5.7 - 2.1}{41 - 2.1} = 0.0926$, and the total weight is 500 g. $\times$ 0.0926 = 46.3 g.

Where the extraction is calculated from assays, as indicated above, the result is called the "apparent" recovery and is not the "actual" recovery based upon the weights of the ore and concentrate. The discrepancy between the two recoveries is due to errors in sampling and assaying. The above formulas are to be relied upon only in so far as the sampling and assaying are correct. While it is not the purpose of this article to discuss the effect of incorrect assays, the bibliography gives some references to that question.[11,12]

Calculations in Cyanide Practice

In cyanide plants the calculation of extraction is complicated by the number of items that must be considered. For a plant using gravity concentration followed by cyaniding of the sand and slime, the extraction by each treatment can be figured separately and all can be combined into one result. If the extraction by concentration is 30 per cent and an extraction of 75 per cent is made on the 70 per cent of the total mill feed that goes to the cyanide plant, the extraction for the whole mill is 30 per cent + (75 per cent $\times$ 70 per cent) = 30 per cent + 52.5 per cent = 82.5 per cent.

A formula for calculating the extraction where combined processes are used is given below[3].

Let E = per cent extraction;
h = assay of feed; H its weight;
m = assay of concentrate tailing; M its weight;
c = assay of concentrate; C its weight;
d = assay of sand head; D its weight;
f = assay of slime head; F its weight;
d_t = assay of sand tailing; D_t its weight;
f_t = assay of slime tailing; F_t its weight.

Then, $H = C + M$;
$M = D + F$;
$Hh = Cc + Mm$;
$Mm = Dd + Ff$;

$$E = \frac{Cc + D(d - d_t) + F(f - f)}{Hh}$$

To eliminate all weight factors, eliminate M from the first and third equations just above:

$$\frac{C}{H} = \frac{h - m}{c - m}$$

Eliminate C from the same two and F from the second and fourth:

$$\frac{M}{H} = \frac{c - h}{c - m}$$

$$\frac{D}{M} = \frac{m - f}{d - f}$$

Multiplying these two gives

$$\frac{D}{H} = \frac{(c-h)(m-f)}{(c-m)(d-f)}$$

Derive similarly the relation

$$\frac{F}{H} = \frac{(c-h)(m-d)}{(c-m)(f-d)}$$

and substitute the appropriate ratios in the expression for E:

$$(7) \quad Eh = \frac{c(h-m)}{(c-m)} + \frac{(c-h)(m-f)}{(c-m)(d-f)}\left(d - d_t\right) + \frac{(c-h)(m-d)}{(c-m)(f-d)}\left(f - f_t\right)$$

It should be noticed that the formula is the summation of the three extractions made separately by concentration, by sand treatment and by slime treatment.

Equation (7) may be simplified somewhat into the form

$$E = \frac{c(h-m) + \frac{c-h}{d-f}[(m-f)(d-d_t) - (m-d)(f-f_t)]}{h(c-m)}$$

At plants where the continuous counter current decantation process is followed the formulas for computing the extraction depend upon the details of the treatment used. An excellent discussion of this subject is to be found in the trade publication of the Dorr Company of Denver entitled "Continuous Counter Current Decantation."[12a and 30]

Screening Practice

Screening tests are a valuable means of controlling some details of milling operations, but, if due care is not exercised in making the tests and if the results are not correctly interpreted, the information obtained may be very misleading.[47] In order to make informing comparisons of screen tests three requirements should be fulfilled.

1. Screens of the same size of aperture and wire should be used for each test.

2. The same method of screening should be followed in all tests.

3. All tests should be run for the same length of time, and preferably in a mechanically operated screening machine.

The word "mesh," meaning the number of openings per linear inch of screen, has no definite meaning. Obviously, the number of openings per linear inch may remain the same for various screens, each of which is made of wire of a different diameter from that of the others, and yet no two screens would have the same aperture. The importance of using a standard series of screens for testing purposes cannot be too strongly urged, for without such a uniformity of screens, published data of tests are rendered worthless. Screen manufacturers have discussed this matter and a set of standard screens has been recommended.[48] This series is based on a 1-mm. opening with the square root of 2, or 1.4142, as the ratio of the openings of successive sieves coarser than 1 mm., and the fourth root of 2, or 1.1892, as the ratio of the openings of successive sieves finer than 1 mm.

Three methods of screening, with some slight variations, are in common use. They are dry screening, wet screening and what may be called a combination method. For dry screening the desired screens are nested in proper order, the sample to be tested is placed on the top or coarsest screen and the set is shaken for a certain length of time. In wet screening the sample is washed through each screen either by means of a jet of water or else in a vessel of water, the respective sizes remaining on the different screens dried and weighed. This is the most accurate method of screening, but much time is required for making a test. In the combination method, the whole sample is first washed on the finest screen used and both oversize and undersize dried. The oversize is then treated as in dry screening, the material passing the finest screen is added to the undersize made by the washing to obtain the final result. This method saves time as against the wet test and is sufficiently accurate for most purposes. All tests should be continued for the same length of time, usually from 10 to 20 minutes; the most suitable time for any particular ore is found by experiment. During any test some material will continue to pass through the screens, though the shaking is maintained for hours. When working on the screening of cement, the United States Bureau of Standards stops a test when the material passing the screen in a given length of time reaches a certain minimum amount.

For ores that have a tendency to fracture into long prisms or needles violent shaking of the screens may cause many particles to pass through a screen, while a gentle screening of the same ore would give a different result. The finest particles of ore tend to stick on the surface of the larger particles and also to adhere to the wires of the screens. Sometimes this fine material forms into balls and remains on the coarser screens. Wet screening is, therefore, more accurate than dry screening. Shaking in a machine eliminates the personal equation, and thus makes it possible to compare different tests satisfactorily. Duplicate tests on the same material should give practically identical results. Since hand screening necessitates the use of only one screen at a time and a screening machine will take the entire set of screens at one time, machine screening becomes imperative where a large number of tests must be made daily.

The results of screening tests are, at best, only approximations of the truth, but that is all the more reason why the greatest care should be exercised when making them. Screen apertures grow larger as the wires wear; evidently, a badly worn set of screens will not give the same results as a new set. In reporting the results, the various sizes should be tabulated and a curve should be plotted from the data thus obtained.

Screen Efficiency

It is possible to make fairly reliable comparisons of the work done by different crushing or grinding machines by means of screening tests. However, it should be remembered that a single test may be quite unreliable as a basis for judging the performance of a machine. Thus, in checking up the work of a ball or tube mill, the average of a number of tests extending over a long period of time, several months or even a year, is the only reliable indicator of the work that the machine is doing.

In a mill where the crushed ore is separated into various sizes by screens, it may be desirable to conduct tests between different kinds of screens or it may be

necessary to determine how much additional feed a certain screen can handle without seriously diminishing its efficiency. The actual amount of screen undersize in the feed must be determined by careful laboratory screening tests. Call this the "actual undersize." Then run a known quantity of feed through the screen and weigh the undersize produced, calling this the "apparent undersize. Then the efficiency of the screen is the apparent undersize divided by the actual undersize.

A test run on 50 tons of feed gave 10 tons, or 20 per cent, as the apparent undersize. A screening test indicated that the feed contained 30 per cent actual undersize. The efficiency of the screen was, therefore, 0.20 ÷ 0.30 = 0.67, or 67 per cent.

Calculating the Efficiency

It is not always convenient to weigh large quantities of material. By the use of formula (2), the efficiency of a screen or trommel can be calculated from screening tests of the feed, oversize and undersize[4]. If f, u and o be used to represent the respective percentages of feed, undersize and oversize that go through the given mesh, we may write

$$E = \frac{u(f - o)}{f(u - o)} \tag{8}$$

In the above example, screen tests showed that the oversize from the screen contained 12.5 per cent of material that should have passed through the screen, and that there was 30 per cent of undersize in the feed. Assuming that the percentage of undersize in the undersize was 100 per cent (no test made on this material), the efficiency of the screen is

$$E = \frac{100(30 - 12.5)}{30(100 - 12.5)} = 0.667 = 66.7 \text{ per cent.}$$

It may be of interest to know how much of the finest sizes in the feed pass the screen. If too little wash water is being used, for instance, some of the fine material will remain in the oversize. Thus, much 200-mesh material may be contained in the oversize of a 2-mm. trommel. To determine the percentage, make screen tests on the feed, oversize and undersize, using a 200-mesh screen. Then use formula (8).

Feed in Closed Circuit

Machines run in a closed circuit always have some oversize returned. This results in a building up of the quantity of material going to the machine until it may reach several times the amount of the original feed before equilibrium is established. Unless this possibility is recognized at the time of installing the machine, a serious overload may be developed. The exact value of the ultimate feed cannot, of course, be accurately estimated beforehand. Crushing tests on the ore will give some idea of the percentage of original feed that will be returned as oversize, but, as the amount of feed increases, conditions of crushing change and the percentage of oversize made does not remain constant. Assuming, however, that the percentage of oversize remains constant, the ultimate feed would be the sum of the infinite geometrical series $x + xr + xr^2 + xr^3 + \ldots = \frac{x}{1 - r}$ where x is the original feed and r is the percentage of oversize. Suppose that a test on a set of rolls indicated that 60 per cent of the feed would be returned as oversize. On a basis of 20 tons per hour the theoretical ultimate load is then $\frac{20}{1 - 60 \text{ per cent}} = \frac{20}{0.40} = 50$ tons per hour.

Split Feeds

Screen tests may be used to show how a product is being split into two parts[5]. At some concentrators, the tailing is sent to a classifier, the spigot product going to make a dam and the overflow going into the pond to be settled.

Let T = total tailing.
P = part going to the pond.
D = part going to the dam.

If a screen test is made on the tailing, say on the 100-mesh size, the respective percentages may be designated by the symbols t_{100}, d_{100} and p_{100}.

For unit weight, $D + P = 1$

Also $Dd_{100} + Pp_{100} = t_{100}$

Eliminating P we have:

$$D = \frac{t_{100} - p_{100}}{d_{100} - p_{100}} \tag{9}$$

Example: At a certain plant screen tests gave 44.4 per cent, 75.2 per cent and 3.1 per cent as the respective values for t_{100}, d_{100} and p_{100}. Substituting in (9), $D = \frac{44.4 - 3.1}{75.2 - 3.1} = 57.3$ per cent to dam, and consequently 42.7 per cent to the pond.

This formula applies equally well where one product is split into two parts or where two are combined into one, but it is reliable only when there is a wide difference between the percentages of the two parts. Thus, if p_{100} and d_{100} were equal or nearly so instead of being 75.2 and 3.1 per cent, the formula would not give correct results. However, this point is not of great importance, since, in most cases to which it would apply, there would be ample difference between the products.

Tonnage of Mills

The large capacity of modern ball and tube mills makes it difficult, if not impossible, to cut out and weigh samples of the feed and discharge. Also it is very hard to determine correctly the percentage of moisture in the pulp. Consider the case where the discharge from the stamp mill battery is screened or classified, the oversize passing to a tube mill working in closed circuit with a drag classifier. The total tube mill tonnage, including returned feed, may be found in terms of the battery discharge as follows[6 and 7]:

Let a = per cent of minus any given mesh in battery discharge.
b = per cent of minus any given mesh in tube mill feed.
c = per cent of minus any given mesh in tube mill discharge.
d = per cent of minus any given mesh in classifier overflow.
B = battery tonnage (dry)
T = tube mill tonnage (dry)

Then $aB + cT = bT + dB$, whence

$$\frac{T}{B} = \frac{d - a}{c - b} \tag{10}$$

which expresses the ratio of tube mill to battery tonnage.

Another method of computing tube mill tonnage is based upon the material in the battery discharge that

does not show in the tube mill product[5]. For example, take the following case:

DATA FROM SCREEN TESTS (CUMULATIVE)

Mesh	Battery Discharge, Per Cent	Tube Mill Feed, Per Cent	Tube Mill Product, Per Cent
10	10.3	5.4	
14	20.3	10.6	
20	30.5	15.9	
28	41.8	21.8	
35	49.5	26.7	1.0
48	56.6	33.2	4.1
65	62.2	41.3	10.6
100	68.2	61.3	30.6
150	74.8	85.7	59.2
200	78.8	93.5	71.9
−200	100.0	100.0	100.0

There is 41.8 per cent of total battery discharge which does not appear in the tube mill product. It had been determined that the mill received 62.5 tons of battery discharge per day. Then 41.8 per cent of 62.5 = 26.12 tons. But this represents 21.8 per cent of the tube mill feed. Therefore the total tube mill feed is 119.8 tons. Also 119.8 tons — 62.5 tons = 57.3 tons as the amount returned to the mill by the classifier. By formula (10)

$$\frac{T}{B} = \frac{0 - 41.8}{0 - 21.8} = 1.91.$$

Since B = 62.5, T = 62.5 × 1.91 = 119.4 tons. The same screen size, 28 mesh, is used in both cases, though any other size should give the same result by the formula if the screen tests have been accurately made.

Formulas for Pulp

The introduction of the flotation process and the methods of treatment used in cyanidation and other hydrometallurgical processes all emphasize the importance of carefully controlling the dilution of the liquid pulp. Most of the following formulas dealing with pulp calculations are from an article by W. J. Sharwood[13].

The weight of solid in a vat filled with a uniform liquid pulp can be determined by drying and weighing a known volume. By proportion, the weight of the entire volume can be calculated. If the specific gravity of the pulp and the density of the dry solid are known, the weight of dry solid per cubic foot as well as many other factors can be computed by the following formulas.

Let d = density or specific gravity of the dry solid (ore, slime or sand)

p = specific gravity of the pulp (weight of 32 cu.ft. in tons)

S = percentage by weight of dry solid in the pulp

R = water ratio of pulp (tons of water per ton of dry solid)

V = volume percentage of solid pulp (cu.ft. solids in 100 cu.ft. of pulp)

F = solid factor, or tons solid in 100 fluid tons (3,200 cu.ft.) of pulp

$k = \frac{100d}{d - 1}$, a constant for any one solid. Used to facilitate computations.

Then the total weight of pulp containing unit weight of solid is R + 1, and the volume of this amount is $R + \frac{1}{d}$, whence the specific gravity of the pulp is $p = \frac{R + 1}{R + \frac{1}{d}}$ as given in formula (12) below. Explicit

TABLE I—FORMULAS FOR WATER AND SOLID IN PULP

	Weight of Pulp	Volume of Pulp	Weight of Dry Solid	Weight of Water	Volume of Water
One ton of pulp, 2,000 lb	1 ton	$\frac{1}{p}$ fluid ton $\frac{32}{p}$ cu.ft.	$\frac{S}{100}$ ton $\frac{1}{R+1}$ ton $\frac{(p-1)k}{100p}$ ton	$\frac{d-p}{p(d-1)}$ ton	$\frac{d-p}{p(d-1)}$ fluid ton $\frac{32(d-p)}{p(d-1)}$ cu.ft.
1 fluid ton of pulp, 32 cu.ft 240 U. S. gallons 200 Imp. gallons	p tons	1 fluid ton 32 cu.ft.	$\frac{(p-1)k}{100}$ ton	$\frac{d-p}{d-1}$ ton	$\frac{d-p}{d-1}$ fluid ton $\frac{32(d-p)}{d-1}$ cu.ft.
1 cu.ft. pulp 7.5 U. S. gallons 6.25 Imp. gallons	62.5 p lb.	1 cu.ft. 0.03125 fluid ton	0.625(p−1)k lb. $\frac{(p-1)k}{3200}$ ton	$\frac{62.5(d-p)}{d-1}$ lb. $\frac{d-p}{32(d-1)}$ ton	$\frac{d-p}{d-1}$ cu.ft.
1 ton dry solid 2,000 lb	(R+1) tons $\frac{100p}{(p-1)k}$ tons	$\frac{100}{(p-1)k}$ fluid ton $\frac{3200}{(p-1)k}$ cu.ft.	1 ton	R tons $\frac{100}{S}$ − 1 ton $\frac{d-p}{d(p-1)}$ ton	32 R cu.ft. R fluid tons
1 fluid ton water, 32 cu.ft 240 U. S. gallons 200 Imp. gallons	$\frac{p(d-1)}{d-p}$ ton	$\frac{d-1}{d-p}$ fluid ton	$\frac{1}{R}$ ton $\frac{d(p-1)}{d-p}$ ton $\frac{S}{100-S}$ ton	1 ton	1 fluid ton 32 cu.ft.

One U. S. gallon of pulp = $\frac{(p-1)k}{12}$ pounds of dry solid. One Imperial gallon of pulp = $\frac{(p-1)k}{10}$ pounds of dry solid.

The relation between metric ton (1,000 kg.) and cubic meter (1,000 liters) is the same as between the ton of 2,000 lb. and the fluid ton of 32 cu.ft. One cubic meter of pulp contains 0.01 (p−1)k metric tons of solid.

functions of d and R as in formulas (11) and (14) are easily had by transposition. Formulas in S are had by substituting appropriate expressions given in (13) and (14). Also, since 100 cu.ft. pulp weighs 100 p units and contains S per cent of solid, the volume of solid in this volume of pulp is its weight divided by its density, or $V = \frac{Sp}{d}$, as shown in formula (16). Formula (15) is thus self-evident.

$$(11)\quad d = \frac{p}{1 - R(p - 1)} = \frac{Sp}{Sp - 100(p - 1)}$$

$$(12)\quad p = \frac{R + 1}{R + \frac{1}{d}} = \frac{100}{100 - \frac{S(d - 1)}{d}} = \frac{k}{k - S}$$

$$(13)\quad S = \frac{100}{R + 1} = \frac{100d(p - 1)}{p(d - 1)} = \frac{k(p - 1)}{p}$$

$$(14)\quad R = \frac{d - p}{d(p - 1)} = \frac{1 - \frac{p}{d}}{p - 1} = \frac{100 - S}{S} = \frac{100}{S} - 1 = \frac{100p}{k(p - 1)} - 1$$

$$(15)\quad F = Sp = \frac{100p}{R + 1} = \frac{100d(p - 1)}{d - 1} = k(p - 1)$$

$$(16)\quad V = \frac{F}{d} = \frac{Sp}{d} = \frac{100(p - 1)}{d - 1} = (k - 100)(p - 1)$$

$$(17)\quad \text{Fluid tons of pulp to give one ton dry solid} = \frac{100}{F} = \frac{100}{k(p - 1)} = \frac{R - 1}{p}$$

For very thin pulps, specific gravity under 1.05, S and F are practically identical, and it may be stated that S or F = k (p — 1). This is an approximation to be used for the overflow of slime settlers, spitzkasten, etc., but its limitation should always be remembered. Table I gives the above relations in a simplified manner and in a form suitable for calculation by slide rule.

Sampling Pulp

The specific gravity of pulp may be determined by several methods. The hydrometer can be used provided the pulp is not extremely thick. However, it is very difficult to keep the coarser material in the pulp from settling, and some of the pulp usually sticks to the bulb of the instrument, consequently the hydrometer usually gives results that are only approximately correct. A very satisfactory method is to use a specific gravity flask[29] made of tin in the form of a cone (Fig. 1). The bottom diameter is 6.5 in. and the side makes an angle of 60 deg. with the flat bottom. The flask should be calibrated by denting the bottom until it holds just 100cc. A tare weight which just balances the flask when it is filled with distilled water should be provided. When the flask is filled with pulp and weighed, the weights in excess of the tare weight give the decimal part of the specific gravity of the pulp. Thus, extra weights of 345 g. mean that the pulp has a specific gravity of 1.345. In general, there is no advantage to be derived from weighing closer than the nearest 5 g. or to within 0.005 of the specific gravity. A 1000-cc. graduate can be used in the same manner. Still another method is to use a bucket that holds one cubic foot of pulp. A bucket 14 in. in diameter will hold one cubic foot when filled to a depth of 11.25 in. The cubic foot point should be marked by boring a small hole through the bucket and inserting a rivet or bolt. In use, a tare weight is used to balance the empty bucket, and the weight of one cubic foot of pulp in pounds times the factor 0.016 gives the specific gravity of the pulp. A modification of this method is to mark a bucket at a point where it holds exactly 100 pounds of water. The weight of this volume of pulp in pounds gives the specific gravity directly by pointing off as decimal all figures to the right of the initial left hand figure (which is always 1).

FIG. 1. SPECIFIC GRAVITY FLASK

Care must be exercised that the sample taken is a true average of the entire volume of pulp under consideration. A small funnel or a rectangular shaped piece of tin made to slip into the neck of the specific gravity flask will enable the sampler to cut a running stream of pulp in a satisfactory manner. If the sample is to be taken from a bucket or other container, the pulp should be stirred vigorously just before taking the sample to insure that the coarser particles have not settled to the bottom of the bucket.

Density of Solids

The specific gravity of a dry solid, sand or slime is best determined by means of a weighing bottle, whose size depends upon the sensitiveness of the balance used. Twenty-five to 50 cc. is a good size for use on a pulp balance and 200 to 1000 cc. capacity should be used on a balance sensitive to 0.1 g. First fill the bottle to the top, or to a well defined mark near the top, with water and weigh. Then empty the bottle and fill half to two-thirds full of the wet sand or slime. Cover with water and shake well, removing the last traces of air bubbles by suction. Fill to the mark with water and weigh. Finally, dump out the sand or slime, dry it carefully and weigh.

$$(18)\quad \text{Density } d = \frac{\text{Wt. of dry sand}}{\text{Wt. of bottle full of water} + \text{Wt. of dry sand} - \text{Wt. of bottle with sand and water}}$$

If the sand is first dried and weighed, and a definite quantity is taken for the test, the result will be too low unless the sand is boiled in water or soaked for a long time. It is very difficult to thoroughly wet dried sand or slime. Again, wet sand must be well dried before weighing, as any contained moisture lowers the apparent density. If the wet sand contains n per cent of moisture by weight, the apparent density $= \frac{100d}{100 + n(d - 1)}$, where d is the true density of the dry material. A quick and closely approximate method for determining the density of a fine concentrate is as follows: Fill a burette to a given mark with pure water at standard temperature, weigh out carefully about 20 g. dry concentrate, and run into the burette by means of a piece of glazed paper, taking care that all goes under water. Note the increased volume due to water displaced by the

concentrate. Then the density of the concentrate is its weight in grams divided by the volume of water displaced in cubic centimeters.

It is often important to know the interstitial space in settled sand or in a filter cake. The maximum volume of voids is obtained when moderately moist material is shoveled or fed by a mechanical distributer into a vat. In a vat of sands having n per cent interstitial space, the speed of percolation will be 100/n times the leaching rate. Thus, if the solution covering a vat of sand drops at the rate of 2 in. per hour, and the interstitial space is 40 per cent, the speed of the solution descending through the sand is $100/40 \times 2 = 5$ in. per hour. Since the depth of the tank or vat is known, the time of draining or the time that a change in the strength of the solution will be apparent in the effluent solution can be closely approximated, provided the material is uniformly distributed in the vat. In settled sands, the interstitial space may range from 40 to 55 per cent.

Let w = grams of material in 100 cc. (including moisture), or lb. per cu.ft. times 1.6.
s = per cent of solids, if material is wet.
d = density of dry solid.
k = 100d/(d — 1), a constant for each material.

For dry material:

(19) Per cent voids or interstitial space $= 100 - \frac{w}{d}$

Thus, for a tailing of 2.65 specific gravity and weighing 80 lb. per cu.ft., the percentage of voids is $100 - \frac{80 \times 1.6}{2.65} = 51.7$ per cent.

For wet material:

(20) Per cent of actual voids or air space $= 100 - w\left(1 - \frac{s}{k}\right)$

(21) Per cent of total space occupied by air and water $= 100 - \frac{ws}{100d}$

(22) Per cent of volume occupied by water $= \frac{w \times \text{per cent moisture}}{100} = \frac{w[100 - s]}{100}$

Thus for partly drained tailing, weighing 95 lb. per cu.ft., with 15 per cent moisture and 85 per cent solids of specific gravity 2.5, the space occupied by air and water is found as follows:

$k = \frac{100 \times 2.5}{2.5 - 1} = 166.7$; $s = 85$ and $w = (95 \times 1.6)$

From (20), $100 - (95 \times 1.6)\left(1 - \frac{85}{166.7}\right) = 25.5$ per cent dry air space.

From (21), $100 - \frac{(95 \times 1.6) \times 85}{100 \times 2.5} = 48.3$ total interstitial space, in per cent of total volume.

The difference of 22.8 per cent is the space occupied by water.

Also from (22), $\frac{(95 \times 1.6)(100 - 85)}{100} = 22.8$ per cent of total space occupied by water.

The capacity of a filter press is most accurately determined by blowing as nearly dry as possible before opening, then selecting several pairs of frames, those of each pair being equidistant from the ends, weighing the entire contents of each frame separately and also determining the moisture in each. Average these figures to get the result per frame and then multiply by the number of frames. A quicker way is to measure the volume of effluent water from the press. This can generally be easily done, as most mills have solution meters on all important pipe lines. Also determine the water ratio, R, of the incoming pulp, and the water ratio, M, of the cake.

A test gave the following results: Water ratio of pulp 4:1; cake contained 40 per cent moisture; total effluent water = 20 tons.

Then R = 4, and $M = \frac{\text{per cent water in cake}}{\text{per cent solids in cake}} = \frac{40}{60} = 0.667$.

(23) Tons solids in press $= \frac{\text{Tons effluent water}}{R - M} = \frac{20}{4 - 0.667} = 6$ tons.

Sluices and Launders

When sluicing wet material from tanks or vats by water or a stream of solution, the calculations are complicated by the fact that water from two sources enters into the mixture.

Let C = per cent dry sand or slime in the material before sluicing
M = water ratio of material before sluicing
= per cent water divided by per cent dry solid
$= \frac{100 - C}{C} = \frac{100}{C} - 1$
R = water ratio of material after sluicing
$= \frac{100 - S}{S}$, where
S = per cent solid in the material after sluicing
E = net sluicing efficiency = tons dry solid moved by 100 tons of added sluicing solution
Q = tons sluicing solution required per ton of dry solid in material sluiced to give a product of S per cent dry solid and R water ratio.

(24) Then $E = \frac{100}{R - M} = \frac{CS}{C - S}$

(25) $Q = R - M = \frac{100}{S} - \frac{100}{C} = \frac{100(C - S)}{CS} = \frac{100}{E}$

(26) Tons water added per gross ton of wet material sluiced $= \frac{QC}{100} = \frac{C(R - M)}{100} = \frac{C}{S} - 1 = \frac{C}{E}$

Thus, if sand in a vat contains 40 per cent moisture, and it is desired to sluice it out so that the resulting pulp will have a water ratio of 3 to 1, we have

$M = \frac{40}{60} = 0.667$; $E = \frac{100}{3 - 0.667} = 42.9$; and
$Q = 3 - 0.667 = 2.33$

In the control of mill operations, it is often necessary to measure the amount of pulp flowing in certain launders. Such measurement is useful for determining the amount of feed going to some machine or the quantity of product coming from the machine.

(27) Tons dry solid per day $= \frac{\text{Pounds dry solid caught} \times 43.2}{\text{Seconds required for catching}}$

(28) Tons dry solid per day $= \left(\frac{2700d}{d - 1}\right) \times \left(\frac{p - 1}{t}\right)$

(29) Tons dry solid per day $= \frac{(27k)(p - 1)}{t}$

where t = time in seconds required to catch one cubic foot of pulp using the entire stream, p is the specific gravity of the pulp, and d is the density of the dry solid, and $k = 100d/(d - 1)$.

Methods of applying the above formulas:

Method No. 1. Turn the whole stream into a suitable bucket or tub, and, when nearly full, switch off stream, noting the exact time of catching by means of a stop watch. Dry the entire catch, weigh and apply formula (27).

Method No. 2. Turn the whole stream into a large tank, switching off after a known considerable interval, say, one minute. Measure the volume and calculate t. In a smaller vessel catch sufficient pulp so its volume can be correctly determined, approximately 1000 cc. or 1 cu.ft. Dry, weigh and calculate the dry pounds of solid per cu.ft. of pulp. Apply the formula:

$$\text{Dry tons per day} = \frac{\text{pounds per cu.ft.} \times 43.2}{t}.$$

Method No. 3. Determine the value of t as in method No. 2. Catch a moderate sized sample of pulp in a bucket and determine net weight. Then dry and weigh the pulp. Calculate S, the percentage by weight of dry solid in the pulp. Then $p = \frac{k}{k - S}$. Apply formula (29).

Method No. 4. Determine t as above. Find the specific gravity of the pulp, p, directly by means of the specific gravity flask. Apply formula (29).

Method No. 5. Single measurement for small flows: In a bucket, marked to hold just one or two cu.ft., catch the pulp, noting exact time. This gives the value of t. Find the weight of the pulp by weighing and deducting the tare of the bucket. p = weight of pulp per cu.ft. times 0.016. Apply formula (29).

Accurate Timing Essential

For accurate results, the time by stop watch for catching samples should never be less than 20 seconds, and a minute or more is to be preferred. Galvanized iron washtubs are convenient for catching small flows and wooden tanks will serve for larger flows. The importance of a sharp and clean cutting of the stream at the time of deflection and when the stream is returned to its usual channel cannot be over-emphasized. The filling of the receptacle takes place all too quickly for the most accurate results and a second's difference between the timing and the actual flow may introduce no small error into the calculations, especially when the report is made in terms of tons of solid per 24 hours. Unless a mill has been designed with launders purposely arranged to facilitate sampling, the ingenuity of the sampling crew will, in many cases, be put to the test to secure a satisfactory sample. It may be necessary to tap a launder beneath a floor or in such a cramped space that, at first, it seems useless to make the attempt. Once a sample has been taken it should be carefully handled until it is ready to be discarded. If any of the pulp is allowed to spill on the floor, the entire sample should be rejected and a new one taken. In case the whole stream cannot be deflected, the sample must be secured by making a cut across the stream as it falls freely through the air. The cutting edge of the sampler must extend through the thickness of the stream and a little beyond to insure a complete cut, and it should move at a uniform rate of speed from one side of the stream to the other. The proper speed to use is dependent upon the volume of pulp that is desired for the sample.

Once a mill has reached the point of steady and continuous operation, it is generally possible greatly to simplify calculations of performance by using certain constants in the formulas[24]. Such quantities as d, k, 27k, etc., change so little that they may safely be considered as constants. Useful curves[22] and charts[21] can be constructed, which show at a glance the relation between density of dry solid, specific gravity of pulp and tons of dry solid per day[25]. Tables showing the contents of dry solid for various sizes of tanks and per foot or inch of depth are valuable time savers.

Formulas for Heavy Solutions

Up to this point all calculations have been made upon the assumption that the specific gravity of the water or solution in the pulp has the value of unity. In some cases the presence of dissolved salts may change the specific gravity of the mill solution so that correct results would not be obtained by using the formulas given above. It is worth noting that a variation in the specific gravity of the solution has a much greater effect than a corresponding variation in the specific gravity of the dry solid. However, such cases may be considered exceptional, and the formulas already stated will usually give satisfactory results and are the ones in common use. Nevertheless, it is well to know their limitations, and formulas in which the specific gravity of the solution is considered as a variable will now be given[9].

Denoting the specific gravity of the solution as D, and using the same notation as in formulas (11) to (17)

(30) $$S = \frac{100(p - D)d}{p(d - D)}$$

(31) $$p = \frac{100D}{100 - S\frac{(d - D)}{d}}$$

(32) $$R = \frac{D(d - p)}{d(p - D)}$$

(33) Cu.ft. of pulp required to make 1 ton dry slime

$$= \frac{32\left(100 - S\frac{(d - D)}{d}\right)}{DS}$$

(34) Weight of dry slime in pounds in 1 cu.ft. of pulp

$$= \frac{62.5d(p - D)}{d - D}$$

(35) Volume of pulp in cu.ft. containing 1 ton dry slime

$$= \frac{32(d - D)}{d(p - D)}$$

(36) Percentage by weight of solution in pulp =

$$100 - S = \frac{100D(d - p)}{p(d - D)}$$

(37) Volume in cu.ft. of 1 ton of pulp =

$$\frac{100 - S\frac{d - D}{d}}{3.125D} = \frac{32}{p}$$

(38) Weight in pounds of 1 cu.ft. of pulp =

$$\frac{6250D}{100 - S\frac{(d - D)}{d}} = 62.5p$$

Variations in temperature cause a change in the volume of wet pulp. The effect of change of temperature is discussed by Clevenger, Young and Turner[10]. This article also contains extensive tables and charts dealing with the specific gravity of slime pulps.

Economic vs. Metallurgical Efficiency

In every mill there are two kinds of efficiency that require consideration. Metallurgical efficiency is concerned with the highest extraction that it is possible for individual machines and the whole plant to make. Economic efficiency is interested only in the greatest profit the plant will yield. If the two are attained at the same time, operating conditions may be said to be ideal, but this is seldom if ever the case. By crowding ore through it a mill can be made to produce a larger tonnage of concentrate than when operating under normal conditions. Though the concentrate is of lower grade, the net result is greater returns from the metals sold and generally greater profits. The metallurgical efficiency or per cent extraction may be much lower than before. Nevertheless, the increased profit more than offsets the greater loss in the tailing and the economic efficiency of the plant is increased[85]. Economic efficiency is calculated from the cost of labor, the cost of supplies and the selling price of metals. It, therefore, contains enough variables to constitute a live question to any mill management.

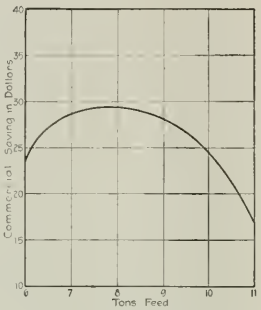


FIG. 2. ECONOMIC EFFICIENCY OF VANNER

As an illustration of the application of the principle of greatest economic efficiency the saving made by vanners treating copper ore will be considered. A chart like Fig. 2 can be made in which the value of the total metal saved per day by a vanner, less the cost of operation, is plotted against the tons of feed coming to the vanner. Such a chart shows at a glance the vanner makes the greatest saving when handling about 7.8 tons of feed per day. Of course, the relation of the product of each concentrating machine to the whole milling process must be remembered. A vanner making a fairly clean concentrate, going to market without further treatment, would not be operated in the same way if it was desired to produce a dirty concentrate which would be cleaned in a flotation machine.

Hand Sorting

The problem whether hand sorting of ore before milling will be profitable or not cannot be decided without making a close study of conditions. Sorting may have for its object the rejecting of material so low in grade that it cannot be milled at a profit, or it may be employed to keep hard and tough waste out of the mill and thereby reduce the cost of fine grinding[62]. Items such as the grade of the rejected material, the cost of sorting, milling and smelting charges and the current prices of metals all enter into the calculations that must be made. These have been expressed in formulas as follows.[21]

Let C = grade of ore before sorting
A = grade of ore after sorting
B = grade of rejected material
N = percentage of the unsorted ore that is rejected
M = milling or smelting charges, including loss in tailing
V = current price of metal exploited
P = cost of sorting per ton of sorted ore.

Then, number of tons of unsorted ore required to produce 1 ton of sorted ore $= \frac{1}{1 - 0.01N}$

Tons of waste from the above unsorted ore $= \frac{0.01N}{1 - 0.01N}$

If there was no sorting the apparent yield from the waste of grade C $= \frac{0.01NCV}{1 - 0.01N} - \frac{0.01NM}{1 - 0.01N}$

This amount is lost by rejecting the waste, and this loss must be overbalanced by the rise in value of the sorted material. This rise is (A — C) V — P. Hence the saving from sorting =

$$[(A - C)V - P] - \left(\frac{0.01CVN}{1 - 0.01N} - \frac{0.01NM}{1 - 0.01N}\right)$$

Now since the values existing in the sorted ore plus that in the waste equals that in the ore before sorting, $A + \left(\frac{1}{1 - 0.01N} - 1\right) B = \frac{C}{1 - 0.01N}$, whence

$$A(1 - 0.01N) + 0.01NB = C \text{ and}$$

$A - C = 0.01N\ (A - B)$, in which case the saving in sorting =

$$\frac{0.01(M - VB)N}{1 - 0.01N} - P.$$

This formula has been worked out on the assumption that M remains constant despite variation in tonnage, and is true for large plants. For small mills the reduction in tonnage resulting from sorting the ore would increase the cost of milling because the fixed charges constitute a relatively high percentage of the total milling cost. The value of M would then have to be changed according to conditions.

Use of Microscope

For some years the microscope has been the chief means of determining the exact nature of different kinds of ores and rocks. Thin sections, when viewed in polarized light, not only show the mineralogical composition of the ores or rocks but also the order of formation of the different crystals and their relations to each other. Many valuable geological deductions have been made from such information. Strange to say, the value of the application of the microscope to ore dressing has not, until recently, been generally recognized. Even in unskilled hands much can be learned by means of the instrument[41]. The measurement of the size of mineral grains, the size of aperture and diameter of the wire in screens, the degree to which crushing must be carried in order to free the grains of valuable minerals in an ore, the amount and condition of the middling product made by any machine and the efficiency of sulphide filming for flotation treatment are easy possibilities for the uninitiated[42]. With a little practice minerals of similar appearance can be differentiated, using the Becke

method of finding the refractive index of grains in mineral powders. The examination of polished opaque sections in reflected light may show the presence in the ore of unsuspected minerals[43]. Through the study of the shape of grains after an ore has been crushed the behavior of the ore under the usual conditions of concentration can be quite accurately predicted. A very complete mineralogical analysis of the crushed ore or concentrate produced can be made by the use of the microscope combined with a separation of the grains in heavy solutions of different specific gravities[40].

This list does not exhaust the possibilities of the microscope as applied to ore dressing. It is safe to say at any plant the cost of the apparatus and the value of the time spent in investigation will be well repaid by the increased efficiency of operation that will result from such a study. The advantages of this method of mill control cannot be too strongly urged.

Bibliography

The attached bibliography contains a list of articles dealing with milling calculations. The list is not a complete one, but it contains the most important references on this subject.

[1]Calculations of Percentage of Recovery; C. W. Wright, *Mining Mag.*, July, 1911.

[2]Concentration Formulas; J. E. Clennell, *Eng. & Min. Jour.*, Oct. 30, 1915.

[3]Calculation of Extraction in Cyanidation; H. A. Megraw, *Eng. & Min. Jour.*, Sept. 6, 1913.

[4]Screen Efficiency; R. S. Lewis, *Met. & Chem. Eng.*, Dec. 15, 1916.

[5]Calculations in Ore Concentration; R. Gahl, *Electrochem. & Met. Industry*, July, 1909.

[6]Tube-Mill Tonnage Calculation; Noel Cunningham, *Met. & Chem. Eng.*, Jan., 1915.

[7]Tube-Mill Tonnage Calculation; Noel Cunningham, *Met. & Chem. Eng.*, Mar., 1915.

[8]Tube-Mill Tonnage Calculation; A. H. Jones, *Met. & Chem. Eng.*, Feb., 1915.

[9]Estimation of Pulp From Its Specific Gravity; F. B. Hyder, *Proc. Colo. Sci. Soc.*, Vol. 19.

[10]Pulp Constants; G. H. Clevenger, H. W. Young, T. N. Turner, *Eng. & Min. Jour.*, Dec. 19, 1914.

[11]The Empirical Formula in Milling Control; A. J. Sale, *Min. & Sci. Press*, June 30, 1917.

[12]Calculation of Extraction in Cyanidation; W. J. Sharwood, *Eng. & Min. Jour.*, Nov. 15, 1913.

[12a] Calculation of Extraction in Continuous Agitation; A. Ham and H. S. Coe, *Chem. & Met. Eng.*, Vol. 19, p. 663.

[13]Measurement of Pulp and Tailing; W. J. Sharwood, *Mining Mag.*, Nov., Dec., 1909.

[14]Barth Slide Rule for Pulp Measurement; C. G. Barth, *Eng. & Min. Jour.*, Aug. 7, 1915.

[15]Solution of Pulp Problems by Graphic Methods; W. J. McCauley, *Eng. & Min. Jour.*, July 17, 1915.

[16]Diagram for Determination of the Solution Ratios of Slimes and Calculations Made Therefrom; Blamey Stevens, *Mex. Min. Jour.*, Nov., 1912.

[17]Chart for Determining Tailings Value; W. J. McCauley, *Eng. & Min. Jour.*, Mar. 27, 1915.

[18]Chart for Tonnage Sampling and Dilution Control; H. R. Robbins, *Min. & Sci. Press*, Apr. 27, 1918.

[19]Specific Gravity Chart; G. B. McLain, *Min. & Sci. Press*, Aug. 3, 1912.

[20]The Estimation of Tonnage; A. W. Allen, *Min. & Sci. Press*, Feb. 24, 1912.

[21]Rapid Estimation of Pulp in Cyanide Tanks; M. R. Lamb, *Eng. & Min. Jour.*, Jan. 15, 1910.

[22]Pulp Curves; C. F. Spaulding, *Min. & Eng. World*, May 22, 1915.

[23]A New Slime Density Table; Lowden, *Met. & Chem. Eng.*, Vol. 10, p. 369.

[24]Slime Pulp Formulas; W. A. Caldecott, *Proc. Chem. & Met. Soc. S. A.*, Vol. 2, p. 837.

[25]Tonnage Formulas; C. E. Dwyer, *Min. & Sci. Press*, May 20, 1916.

[26]Concentration Formulas; W. R. Flynn, *Eng. & Min. Jour.*, April 1, 1916.

[27]Calculation of Recovery in Concentration; T. J. Hoover, *Eng. & Min. Jour.*, June 11, 1910.

[28]Calculation of Percentage of Recovery; T. J. Hoover, *Mining Mag.*, Aug., 1910.

[29]Practical Applications of the Specific Gravity Flask; H. Stadler, *Jour. Chem. Met. & Min. Soc. of S. A.*, Nov., 1911.

[30]Continuous Counter Current Decantation; Trade catalog of the Dorr Co., Denver.

[31]Formulas for Ore Sorting; G. Luna, *Eng. & Min. Jour.*, June 29, 1918.

[32]Milling vs. Hand Sorting of Lead Ore; R. S. Handy, *Min. & Sci. Press*, Mar. 15, 1913.

[33]Value of Coarse Concentration; H. M. Adkinson, *Eng. & Min. Jour.*, July 22, 1911.

[34]Application of Hindered Settling to Hydraulic Classifiers; E. S. Bardwell, *Trans.*, A. I. M. E., Vol. 46, p. 266.

[35]The Anaconda Classifier; R. Ammon, *Trans.*, A. I. M. E., Vol. 46, p. 277.

[36]Experiments on the Flow of Sand and Water Through Spigots; R. H. Richards and B. Dudley, Jr., *Trans.*, A. I. M. E., Vol. 51, p. 398.

[37]Free and Hindered Settling of Mineral Grains; A. O. Christensen, *Eng. & Min. Jour.*, Sept. 11, 1909.

[38]Specific Gravity Apparatus; J. M. Lillegren, *Min. & Sci. Press*, Feb. 13, 1915.

[39]New Method of Separating Materials of Different Specific Gravities; T. M. Chance, A. I. M. E. Meeting, Feb., 1918.

[40]Method of Making Mineralogical Analysis of Sand; C. W. Tomlinson, *Trans.*, A. I. M. E., Vol. 52, p. 852.

[41]Use of the Microscope in Mining Engineering; F. W. Apgar, *Trans.*, A. I. M. E., Vol. 57, p. 65.

[42]The Microscope in Ore Dressing; C. Y. Clayton, *Chem. & Met. Eng.*, July 15, 1918.

[43]The Reflecting Microscope in Mining and Metallurgy; J. C. Ray, *Min. & Sci. Press*, June 6, 1914.

[44]Grain Size Measurement; Z. Jeffries, *Met. & Chem. Eng.*, Feb. 15, 1918.

[45]Laboratory Method for Determining the Capacities of Slime Settling Tanks; H. S. Coe and G. H. Clevenger, *Trans.*, A. I. M. E., Vol. 55, p. 356.

[46]Methods for Determining the Capacities of Slime Thickening Tanks; R. T. Mishler, *Trans.*, A. I. M. E., Vol. 58, p. 102.

[47]Suggested Method of Standard Screen Tests; L. Robey, *Min. & Sci. Press*, Mar. 28, 1914.

[48]Adoption of Standard Screens for Screen Analyses; R. H. Richards, *Min. & Eng. World*, Feb. 15, 1913.

[49]Standard Screen Scale for Testing Sieves; *Trans.*, A. I. M. E., Vol. 57, p. 472.

[50]Sorting and Breaking Ore in the Rand District; F. L. Bosqui, *Trans.*, A. I. M. E., Vol. 52, p. 28.

[51]Some Facts and Figures of Sorting on the Rand; L. D. Huntoon, *Eng. & Min. Jour.*, Nov. 27, 1909.

[52]Hand Sorting of Mill Feed; R. S. Handy, Paper read at Sept., 1918, meeting A. I. M. E.

[53]Economic Efficiency in Lead Concentration; R. S. Handy, *Mines & Minerals*, Nov., 1912.

Navy Department to Sell Explosives Plant

The Navy Department has begun the sale of surplus material in its possession consisting of an explosives plant at Mt. Union, Pa., lumber, chemicals, machinery, etc. Sealed proposals have been asked for on a small quantity of condemned stores and the balance will be placed on sale as fast as it is released. The disposition of the material is being made through the bureau of supplies and accounts, Navy Department, of which Rear Admiral McGowan is chief, under the direction of Lieut. C. G. Peterson.

The property which will be offered for sale by the Navy Department is small compared with the surplus material of the War Department. One of the largest items is the explosives plant at Mt. Union, which is valued at $1,500,000. Only the TNT unit will be placed on sale, the powder section having been disposed of to the Aetna Powder Co. The Navy Department announces that the purchaser will have the option of placing the plant in operation or of scrapping it.

A large quantity of copper purchased by the Department at high prices will not be sold, but will be stored for the future use of the Navy.

Storage Tanks Made of Reinforced Concrete*

Details of a Large Installation of Concrete Tanks—Preliminary Tests on Permeability for Water and Ammoniacal Liquor—Drawings, Construction, and Costs

By F. W. FRERICHS

ABOUT a year ago it became necessary to construct large storage tanks for ammoniacal liquors. Usually such tanks are made of steel, but on account of the war steel plates were not obtainable and concrete was the next best material which was available for the construction. By preliminary experiments it was proved that good concrete was not materially affected by crude ammoniacal liquor, and in order to ascertain the permeability of concrete walls by water and aqua ammonia four small experimental tanks were constructed and subjected to systematic tests.

The accompanying sketch (Fig. 1) illustrates the construction of the tanks, one of which was made from cement concrete consisting of one part cement, two

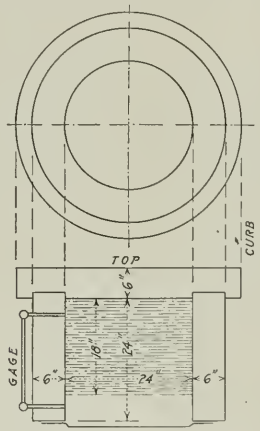


FIG. 1. SKETCH SHOWING CONSTRUCTION OF THE TANKS

parts sand, and four parts gravel. This tank was designated by the letter "A." The three other tanks were made from the same concrete mixture with the sole difference that in tank "B" 2 per cent hydrated lime was added to the cement before mixing, while tanks "C" and "D" contained 2 per cent each of two other waterproofing materials (stearates) of the market.

Each tank carried a gage glass on the side in which the level of the liquid in the tank could be observed. A sheet-iron circular cover was cemented to the top to prevent loss by evaporation. During the test period the tanks were standing in the open air exposed to the hot summer sun and the outside surfaces appeared dry. The inside area of each tank was 15.70 sq.ft.; the outside area was 35.74 sq.ft.

*Read before the Chicago meeting of the American Institute of Chemical Engineers, Jan. 17, 1919.

After ten days' drying the tanks were subjected to the following tests with a view of ascertaining the permeability of concrete by water and ammoniacal liquor:

Series I.—Permeability for Water

All four tanks were filled with water 18 in. high to within 6 in. from top, and the iron covers luted on tight with cement. Readings of water in gages were taken every day at 3 p.m. and the drop in the water level was recorded as read in inches.

	I		II				III				IV			
	Temp.,		Drop in Surface				Evaporation				Evaporation			
1917	Max.	Min.	A	B	C	D	A	B	C	D	A	B	C	D
	Deg. F.	Deg. F.	In.	In.	In.	In.	Cu.In.	Cu.In.	Cu.In.	Cu.In.	Cu.In. per Sq.Ft. Outside Area.			
July 13	96	69	0.00	0.00	0 00	0.00								
14	81	67	0.63	0.38	0.13	0.75	285	172	59	339	11.6	6.9	2.4	13.5
15	84	67	0.75	0.38	0.19	0.94	339	172	76	425	13 5	6.9	3.0	17.0
16	83	68	1.00	0.38	0.19	1.19	452	172	76	538	18.0	6.9	3.0	21.5
17	82	64	1.19	0.50	0.38	1.38	538	226	172	624	21.5	9.0	6.9	25.0
18	83	68	1.38	0.50	0.38	1.50	624	226	172	678	25.0	9.0	6.9	27.1
19	86	69	1.56	0.56	0.38	1.63	705	253	172	737	28.0	10.1	6.9	29.5
20	90	68	1.69	0.63	0.38	1.75	764	285	172	792	30.5	11.4	6.9	31.7
21	90	69	1.81	0.69	0.44	1.88	818	311	199	850	32.7	12.4	8.0	34 0
22	93	73	1.94	0 78	0 47	2.00	877	352	212	904	35.0	14.1	8.5	36.2
23	87	67	2.06	0.88	0.50	2.13	931	397	226	963	37.2	15.9	9.0	38 5

Column I. Temp. max. and min. from Weather Bureau.
Column II. Drop of level in gage in 1/100 inches.
Column III. Evaporation in cu.in.
Column IV. Evaporation in cu.in. per sq.ft. outside area of 25 sq.ft. exposed to atmosphere.

Counting the decrease for the first day for saturation of the concrete, then the average evaporation per day per sq.ft. outside area of 25 sq.ft. has been for A 2.8 cu.in.; B 1.0 cu.in.; C 0.7 cu.in.; D 2.8 cu.in.

Series II.—Permeability for 18-In. Aqua Ammonia

All four tanks were filled with aqua ammonia 18 in. high to within 6 in. from top, and the iron covers luted on tight with cement. Readings of level in gage were taken every day at 3 p.m. and the drop of level was recorded in 1/100 in.

	I		II				III				IV			
	Temp.,		Drop in Surface				Evaporation				Evaporation			
1917	Max.	Min.	A	B	C	D	A	B	C	D	A	B	C	D
	Deg. F.	Deg. F.	In.	In	In.	In.	Cu.In.	Cu.In.	Cu.In.	Cu.In.	Cu.In. per Sq.Ft. Outside Area.			
Aug. 6	85	68	0.00	0.00	0 00	0 00								
8	85	71	0.31	0 31	0.13	0.25	140	140	59	113	5.6	5.6	2.4	4.5
9	78	64	0.56	0.44	0.25	0.38	253	199	113	172	10 1	8 0	4.5	6.9
10	76	60	0.94	0.50	0.31	0 44	425	226	140	199	17.0	9.0	5.6	8.0
11	80	63	1.25	0.56	0 38	0.50	565	253	172	226	22.6	10.1	6.9	9.0
12	79	65	1.38	0.63	0.44	0.56	624	285	199	253	25 0	11.4	8.0	10.1
13	84	66	1.50	0.69	0.50	0.61	678	312	226	276	27.1	12.5	9.0	11.0
14	83	68	1.75	0.71	0 56	0.63	791	321	253	285	31.6	12 8	10.1	11.4
15	80	69	1.81	0.73	0.63	0.67	818	330	285	303	32.7	13.2	11.4	12.1
16	86	71	1.94	0.75	0 69	0.71	877	339	312	321	35 1	13.6	12.5	12.8
17	91	72	2.06	0 81	0.75	0.75	931	366	339	339	37.2	14.6	13.7	13.7

Columns I—IV designate the same as in Series I.

The aqua ammonia in the tanks did not perceptibly decrease in strength in the ten days' test. The tanks were exposed to the hot sun.

Counting the decrease of the first two days for saturation of the concrete, then the average evaporation per day per sq.ft. outside area exposed to the atmosphere (25 sq.ft.) was for A 3.5 cu.in.; B 1.0 cu.in.; C 1.25 cu.in.; D 1.02 cu.in.

After these tests were made the tanks were dried out and painted on the inside with three coats of raw gas tar. The tar used for the first coat was thinned down with about 10 per cent turpentine, which caused the tar to penetrate about one-eighth of an inch into the concrete. After one week's drying the tanks were tested again with ammoniacal liquor and during several months there was no appreciable loss of their contents.

Three Storage Tanks

Encouraged by these results three large storage tanks were built by plans which were prepared by Messrs. Brenneke & Fay, civil engineers of St. Louis, who describe them as follows:

Three tanks were built in a concrete pit 47 ft. 2 in. wide, 130 ft. long and 30 ft. deep. The excavation for the pit was made in the slope of the river bank partly in earth and partly in solid rock. The bottom, side and end walls rest on solid rock. The walls of the pit are designed as vertical reinforced concrete slabs, their bottom edge being heeled into a trench cut in the rock and the top edge reinforced with a flange acting as a horizontal girder. The tops of the walls are tied across to the opposite walls at intervals by a system of longitudinal and transverse beams which are reinforced to act in either tension or compression, these beams being supported at their intersections by columns from the bottom of the pit. The walls of the pit are so reinforced as to resist hydrostatic pressure in either direction. The north and east walls, which are the upstream and river walls, are also designed to resist the impact of running ice during a high water stage.

After the side walls were built the bottom of the pit was covered with concrete to make it tight, and is reinforced with steel in both directions as a precaution against any upward pressure that might occur during high water on account of fissures or cavities in the rock underneath. In the concrete bottom, sumps are provided to collect rainwater, seepage or leakage from the tanks. Circular chases were also left in the concrete bottom in which to heel the side walls of the tanks in order to get a tight joint between the walls of the tanks and the bottom. The longitudinal and cross beams between the walls at the top of the pit are also designed to support a concrete floor should a building be constructed over the pit in the future. All concrete work in the pit is composed of one part red ring portland cement, two parts sand, and four parts washed and screened Meramec gravel. The accompanying plans (Fig. 2) show the general design, dimensions and details, as well as the steel reinforcement of both the pit and tanks.

The three tanks are 35 ft. inside diameter, and 26 ft. deep. The walls are 7 in. thick, and the tops are covered with a concrete roof 6 in. thick. Manholes are provided in the roof of each tank and are constructed with a double curb of concrete 6 in. high around the

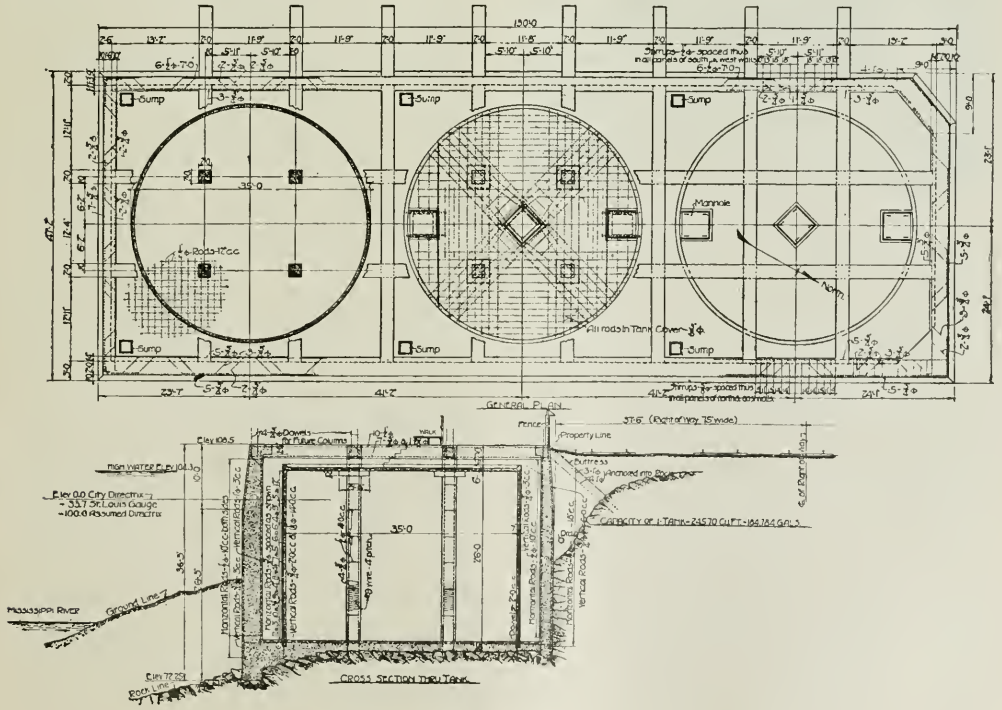


FIG. 2. PLAN SHOWING GENERAL DESIGN, DIMENSIONS AND DETAILS

openings. The manholes have metal covers in the form of an inverted pan, the edges of which rest in the groove between the curbs, and the groove is filled with water to form a seal to prevent the escape of gases from the tank.

The roofs of the tanks are also constructed with a curb about 6 in. high around the edge so that the entire roof can be covered with water as an additional seal against the escape of gases through the concrete.

Plain Concrete Tanks Watertight

As the tanks are to contain ammonia liquor it is essential that they should be tight. Preliminary to their construction several small experimental tanks about 3 ft. in diameter were built with and without waterproofing compounds mixed with the concrete. The plain concrete tanks apparently were as watertight as those in which compounds were used. From the information obtained from these experimental tanks, and from various other sources, it was concluded that waterproof tanks could be built of plain concrete. It is essential that all joints in the walls be eliminated and the concrete be mixed dry, that is, of a consistency of a stiff mortar and then thoroughly rammed. In order to eliminate all joints it was necessary to arrange to concrete continuously day and night from the time the walls were started until they were finished. The vertical reinforcing rods were first secured in position,

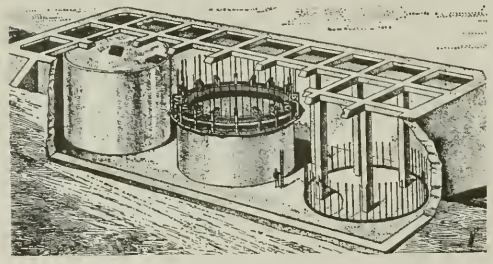


FIG. 3. PERSPECTIVE DRAWING OF THE THREE TANKS

sixteen of which were 1⅛-in. diameter plain rods located equidistant around the circle, the balance of the rods being ¾-in. diameter deformed rods.

On each of the 1⅛-in. vertical plain rods was placed a metal sleeve constructed with a pair of metal jaws so arranged as to grip the rod wherever the sleeve was placed. The outside of the sleeve was threaded full length and provided with a large nut. From these sleeves were suspended wooden yokes having a metal bearing on the nuts on the sleeves. To the yokes were attached the sliding forms for the tank wall and also the working platform for the men.

The general construction of the yokes, forms and platform is indicated on the accompanying perspective drawing (Fig. 3). The forms were about 5 ft. high made in sections bolted together. The faces were made of quarter-sawed tongued and grooved material laid vertically. After the horizontal reinforcing for the lower 5 ft. of tank was wired in place, the forms were placed and concreting started. The concrete was delivered by a chute from the mixer at the top of the pit to the working platform and deposited into the forms in thin layers and thoroughly tamped. As soon as the concrete reached the top of the forms, the movement of the forms was started by turning up the nuts on the threaded sleeves. This work was carried on continuously day and night, no stopping in the work of concreting or movement of forms being allowed from the time of starting until the wall was finished.

The placing of the longitudinal reinforcing steel was carried on at the same time. As soon as a nut reached the top of its sleeve the load on it was relieved and the nut backed down to the bottom and the sleeve slid up the rod and secured to a new position, and the process of jacking continued. The movement of the forms was made uniform by taking an equal number of turns on each nut in rotation. The rate of movement varied from about 8 in. per hour during the cool hours before sunrise to about 14 in. per hour during the heat of the day, as the time of setting of the concrete was affected by the temperature of both materials and atmosphere. After the top of the wall was reached and the concrete set, the forms were disconnected and removed and used again on the next tank. The concrete roofs were put on at a later date after the walls were thoroughly set.

The concrete in the tank walls is composed of one part red ring portland cement, two parts sand and three parts washed and screened Meramec gravel.

After the concrete work was completed and the tanks dried out the bottom, sides and roof on the interior were coated with three coats of tar applied with a brush as an additional precaution against leakage of liquid gas.

The tanks were then tested by filling with water. In the walls of the first tank built there was some leakage through slight lifting cracks which was due to the slow movement of the forms. These lifting cracks were avoided by more rapid movement of forms on the balance of the work. The leaks gradually healed up and have practically disappeared.

The capacity of each tank is about 185,000 gal., and cost approximately $10,000 exclusive of the tank pit.

Plan to Dispose of Surplus Government-Owned Nitrate

A meeting for the purpose of taking up the disposition of surplus stocks of sodium nitrate in this country was held recently in the office of the Director of Sales and was attended by a representative of the War Trade Board, a representative of the War Industries Board, the Nitrate Committee, and representatives of the Sales Office.

It developed at this meeting that the Government has a surplus of approximately 226,000 tons of sodium nitrate in the United States and 120,000 tons in Chile. It was decided that the importers should dispose of the surplus in this country and that the Government should endeavor to dispose of the surplus in Chile to foreign interests. A committee was appointed by the Nitrate Committee to draw up an offer to the Government to buy the surplus nitrate, the Government to allow them a certain fixed amount per ton to cover cost of selling.

The operation outlined is simply a continuation of the method under which the consumers have obtained sodium nitrate through the importers since November, 1917.

Economics of the Zinc Industry: A Prophetic Discussion

An Expansion of the Zinc Industry Is Not to Be Obtained by Advertising and Promoting New Uses Alone—In Addition Metallurgical Operations Must Be Perfected and Lower Costs Obtained

By PARKER C. CHOATE

WITH the close of the world war the zinc industry finds itself in a condition demanding serious consideration, with more radical reconstruction in prospect than in almost any other large industry.

Capacity for overproduction exists equal to the extent of the entire pre-war market. The present price of spelter is hardly adequate to meet expenses, even crediting the value of the acid by-product. The price of sulphuric acid will drop, since its production has been greatly stimulated by the war and the consumption has suddenly been heavily curtailed. The labor charges are exorbitant and at best are a large factor in the existing methods of spelter manufacture. The fuel (coal) has increased abnormally in price due to increased labor and freight. Freight tariffs have increased so much that the industrial economic balance is seriously affected, since the zinc smelter must not only meet long freight hauls on ore but a distant distribution of acid and spelter.

Cost to Remain High

Thus the cost of making spelter, of raw material (ore, clay, coal), of labor and freight will probably remain high for a long period, while the selling prices of zinc and acid appear to be on the decline owing to overproduction. To comply with nature's law of demand and supply the best course seems to be to increase spelter consumption and at the same time to decrease the cost of production, since a decreased selling price is the surest means of increasing sales. The American Zinc Institute has already been formed for the purpose of regulating and finding new markets for the metal at home and abroad. This united effort is the first instance of co-operation within the zinc industry, and is very creditable, but so far it has appeared to overlook the real essence of its purpose—largely increased sales—because it is not proposing any radical steps to decrease present manufacturing costs. To increase a market by finding new uses for a commodity by advertising is a favorite method, but it tends to increase the cost of production by the added costs of the advertising propaganda, while the increase of a market by a decreased offering price of the product is automatic. It would therefore seem desirable to discuss the problem of how to produce spelter more cheaply, as the problem of increased sales can safely be left to the advertising agencies now available. However, both methods are very desirable in this instance, since zinc can undoubtedly be advantageously adapted to many new uses.

The best economic weapon with which to meet a bad business situation is not employed or discussed because to decrease the cost of production involves technology and mental development seldom present on the board of directors.

Centers of Present Spelter Production

The sheet-zinc fields lie in the Middle West and have furnished the main ore supply in the past because of the quality of the ore. These fields still play a major but declining rôle because the vein deposits, chiefly of the Northwest, yield the zinc unit at a cheaper mining cost when it is shared by other metals contained in the ore. Fortunately for the older practice, the metallurgy involved in handling the large deposits of cheap vein zinc has been more difficult and so far neglected by the non-technical minds in control of the spelter trade.

When the zinc industry started in America it was natural to locate the manufacturing plant near a bed of coal, because it required several tons of coal for each ton of zinc ore reduced. Clay beds also played a part in the location, as the zinc retort was a prominent item of operating expense. Thus the industry became centered in the Middle West on coal beds and utilized the best-quality zinc ore from the nearest sheet ground. Gradually the fuel consumption has been reduced and is now about one ton of coal for one of ore; a poorer and cheaper quality of zinc ore is also handled and sulphuric acid manufacture installed in order to mitigate the SO_2-gas nuisance caused by the necessary desulphurization.

Future Importance of Vein Ores

The profits on acid and metal-carrying residues have decreased the cost of producing spelter and therefore complicate the economics, but it is unquestionable that the conditions as just outlined and which have created the old zinc industry are now passing.

It is common knowledge that the Northwest and in fact all the Rocky Mountain region contain immense quantities of vein zinc ores of complex character but which are not now carried to market to any extent. The contained zinc has been a curse to the blast-furnace operator smelting for other metals, who consequently penalized the shipper. However, concentration followed by selective flotation is rapidly changing this situation, so that increasingly large quantities of zinc mineral separated from complex vein ores are now being sold to zinc smelters.

The freight tariffs on the long haul from Western mines to the distilling plants in the Central states has been a serious and increasing item of expense, and the inevitable issue will be that the zinc concentrates will be reduced to spelter at or near the point of origin. Ample coal and proper clays do not exist there, nor can sulphuric acid be produced on account of the dis-

tance to market. Fortunately, however, water power does exist as a commodity now undeveloped and valueless; but developed it can compete with coal as a heating agent. Research is also perfecting metallurgical processes to use this hydro-electric power to reduce the heavy labor bill during distillation, to avoid the excessive use of clay and coal and to save more directly a larger proportion of by-product metals.

Leach-electrolysis of complex zinc ores is already established and controls the pure zinc market, but is not a serious competitor of ordinary metal. Electric zinc smelting is probably coming, but presents difficulties in the condensation of the metallic vapor. Electric retorting will probably be the most serious competitor of the present gas retorting, as it eliminates coal, clay and excessive labor bills, and can be installed in small units at any mine having water power. This process will use the lime-briquet reduction process, thus avoiding roasting and acid problems, and by saving the associated lead and silver in the act of distillation without the cost of residue smelting will produce spelter at a materially lower cost than is at present possible in the gas-fired or coal-fired retort.

The coming cheap electrical manufacture of spelter at the prolific vein mines using the new processes of technology presents the strongest and most immediate incentive for the distiller to reduce his now excessive cost of manufacture and to improve the metal extractions. It will produce a market for the miner operating a complex zinc ore property not now profitable; and their number is legion. The gas-retort operator must meet this competitor or disappear.

Improved Gas Retorting

I have already discussed the principles which appear to underlie any radical reduction of the cost of retort spelter in Chemical & Metallurgical Engineering, July 1, 1918 (Vol. 19, p. 20), under the title "Research Preparedness in the Zinc Industry." Briefly, the scheme involves costless fuel, lime-briquetting and continuous retorts—admittedly radical changes scrapping the present zinc plants except the organization, general metallurgical utilities and buildings.

Located on the lignite and bituminous fields of the Middle West, the zinc industry has at hand an immense latent gas supply. To make other than a low-grade producer gas will yield a carbonaceous residue, and as the coals are not free coking, the sale of the pulverized residue as such is out of the question. Hard briquetted with its own tars, however, it is a better domestic fuel than coke, and the public will pay a price for such briquets that will pay all mining and treatment costs. Thus an excess retort gas of good calorific power can be obtained as a by-product at no cost to be used in zinc distillation, while the original carbon residue is the best zinc-retort carbon mix obtainable.

Due to the character of the flotation slimes that constitute an increasing proportion of the distiller's ore-supply the act of desulphurization is rendered continually more difficult. Returns from sulphuric acid bolster up the roasting department, but its profitable manufacture is becoming questionable, even though it is a hygienic necessity. The logical solution is the adoption of the lime-reduction process, retorting the briquets of raw ore, a process which has demonstrated its ability to decrease largely the wear and tear on retorts, to increase materially the metal extraction, to conserve about 33 per cent in time of distillation with a corresponding saving in fuel and labor and to be about the only good way to handle the fine flotation slimes.

The continuous vertical zinc retort, with center condenser of large diameter, preheating the charge in the top section, conserving waste heat by preheating the combustion air and gas in the bottom or discharge section, will in the first place greatly reduce the labor bills, but will also conserve heat units beyond the best systems now in use. A form of vertical retort is reported in use in Germany, but America will produce an advanced and durable type using the non-slagging lime briquet.

The technical mind realizes that these economies in gas-fired distillation are practical and must be embraced if the present industry is to be protected. They will cheapen the cost of manufacture and enable the use of the cheapest zinc-unit irrespective of quality.

Economic Summary

Gas-retort practice can conserve one-half or more of its labor bills by adopting the large continuous vertical retort. Fuel gas and retort mix can be obtained at no cost (perhaps at a minus cost, or profit) by entering the lignite retorting business and supplying a large consuming public with suitable domestic coal briquets.

Further conservation in fuel gas, carbon mix and retort wear and tear is obtainable by using the lime-reduction process, at the same time using cheaper complex ores and giving better metal extractions.

In this manner, it is probably practicable to distill a ton of zinc ore with less than one-third ton of coal or its equivalent gas. While it is undesirable to enter into definite figures as to the cents per pound saved by this or that departure from the existing crude practice, it seems obvious that more than 50 per cent of the present cost of spelter can be conserved while utilizing a cheaper zinc unit than the usual concentrate from the Missouri-Kansas-Oklahoma fields.

The present zinc industry must take such steps or practically be driven out of business by more advanced operation. An increased market for spelter cannot be of aid if the present manufacturing cost is to remain.

United Economic Research

While the American Zinc Institute is preparing a market by united effort, it is advisable to unite in large scale research with a view of enabling the present industry to maintain itself, to serve the public with better technical efficiency and to aid in the larger distribution of zinc, by offering the metal at a lower price.

The usual research of individual corporations is quite inadequate in finance or scope to meet such an issue as now presents itself, and the cost of erecting and operating a commercial unit is larger than most zinc companies care to assume. No doubt inventions will be involved and compensation should be paid to the designer or creator. Under united experimental action the entire cost of the tests can be assumed by the agents who perfect the technical advance, the so-called cost of research thus becoming a prepayment on account of the royalties that would later accrue.

While it may require a quarter of a million dollars to practically develop the obvious advances, such a cost will be small as compared to the total which will be incurred by the individual efforts of each corporation experimenting with this and that process or device, or of paying large royalties to some exploiting corporation, which, like Minerals Separation, obtains control of essential patents.

The outlined research is known to be practical, and all that is needed is a balanced assembly to produce the desired result, so that the operating and engineering staff of the contributing zinc corporations can copy and adapt it to suit their several needs. The writer two years ago pointed out that these improvements in the zinc industry consisted of a chain of acts, radical, but connected. To test or adapt one of the proposals will lead to another, so that only a complete installation will yield the desired result.

The subject is submitted for thought and discussion.

Essex, Mass.

Corrosion of Brass in Sea Water

By Paul T. Bruhl

THE corrosion of brass has long been investigated, notably by a committee appointed by the Institute of Metals (London), and experiments have been conducted not only to throw light on the various factors governing the rate of corrosion but also to suggest some other alloy as a substitute for brass if sufficiently effective protective measures cannot be found.

Brass may be said to corrode in two ways; in the first the action is merely mechanical and the metal is abraded; in the second and more dangerous way it is either attacked uniformly over its entire surface or corrosion is strongly localized and we have the phenomena of dezincification and pitting. As the strength of a chain is that of its weakest link, so that of a condenser tube depends upon the length of time which suffices for the development of the first perforation.

In the investigation of the effect of strain it was found that the method of manufacture does not permit of any difference in solution pressure greater than 0.0002 volt. This factor contributing to the rate of corrosion is therefore not a serious one; the anodic areas merely act as loci at which corrosion tends to start and from which it spreads over the whole surface.

The bearing on the subject of annealing—with respect both to time and temperature—has been shown to be small, though annealing by increasing the electromotive force increases the liability to attack. It must always be remembered, however, that corrosion is a complex problem and the reactions it involves are difficult to foretell; so that observations made at the beginning may not hold good at the end of an experiment.

Rolling of the metal has an influence inasmuch as it increases the tendency to corrode by imparting to the metal an added energy, though the solution pressure is diminished by the closer agglomeration of the molecules.

Bilge water and organic oils are harmful, the former owing to the formation of corrosive sulphur compounds, the latter because of the decomposition by steam into products containing free acid.

Stray currents of electricity undoubtedly exert a pernicious effect by causing more rapid removal from the solution of the charged ions. Mr. Milton in discussing this point said, "If, for instance, there is a leakage from the positive cable in such a position that part of it proceeds to the sea (earths) through the water flowing through the condenser tubes, which are, of course, clean metal, instead of through the hull of the vessel, which is kept painted in order to prevent any actual contact between the iron and the sea water, some electrolytic action must take place in the tubes themselves."

I studied the influence of various corrosion products on the rate of corrosion by arranging them in the electrochemical scale and by determining their specific resistances.

The following results, which are approximate, were obtained:

1. Brass.
2. Zinc oxide.
3. The oxychloride.
4. Iron oxide.
5. Cuprous oxide.
6. Cupric oxide.
7. Iron hydrate.
8. Basic zinc carbonate.
9. Coke.
10. Basic copper carbonate.
11. Tin oxide.

The next table gives the order of resistance per cubic centimeter in ohms in the moist state.

1. Coke, less than 1000.
2. Cuprous oxide, less than 1500.
3. Iron oxide, less than 2800.
4. Basic zinc carbonate, less than 4000.
5. Basic copper carbonate, less than 6500.
6. Zinc oxide, less than 7000.
7. The oxychloride, less than 7500.
8. Cupric oxide, less than 10,000.

We see from the tables that the rate of corrosion must be to some extent increased by the mutual interaction between the products of corrosion and by the formation of voltaic couples with the metal itself.

The main consideration in any research on the corrosion problem ought to be the determination of the circumstances which give rise to pitting. Three factors govern the positions of the serious pits; mechanical defects, the presence of certain deposits which act as cathodic centers, and dezincification, that is to say, the preferential solution of the zinc. A spill must be a source of danger (though some do not hold it to be so) as the metal wall where it occurs is thinner and hence corrosion has not so far to proceed to cause a perforation. The deposits which are generally conceded to be injurious are the green oxychloride (which promotes dezincification), carbon and ferric hydrate.

A study of the effect of physical constitution on corrosion has been made. For instance, Muntz metal, which contains 60 per cent copper and 40 per cent zinc, is built up of the alpha and beta phases and the voltaic action between the two accelerates the rate of corrosion, so that at first, before secondary reactions set in, Muntz metal corrodes faster than 70/30 brass which consists of the alpha phase only.

Control of the condenser temperature through the provision of an adequate area of condensing surface, the use of electrochemical protection, the substitution for brass of other metals such as phosphor-bronze, monel metal, alloys of copper and aluminium, and brass with 2 per cent lead, have all been suggested as aids to the partial prevention of corrosion.

Other interesting observations that have been made are that up to a certain point dilution or aëration of the sea water, and in general a rise in temperature or an increase in the amount of CO_2 present, promote the corrosion of brass.

Laboratory Electro-Deposition Plant

By Carle R. Hayward

ONE of the required operations in the metallurgical laboratory of the Massachusetts Institute of Technology is a study of the electrolytic refining of copper. For this purpose a series of five tar-lined vats were used for many years, but part of the value of the operation was lost because the students could not see what was taking place in the vats.

When equipping the new laboratory in Cambridge the writer designed a set of tanks with glass sides which

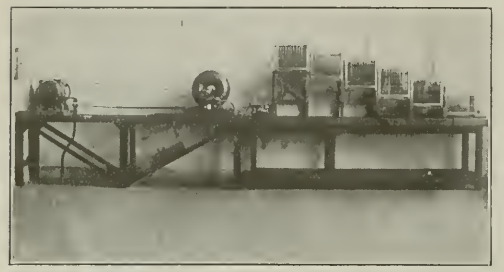


FIG. 1. LABORATORY APPARATUS FOR THE ELECTROLYTIC REFINING OF COPPER

have given excellent satisfaction. A description of the plant will doubtless prove of general interest.

A photograph of the apparatus is shown in Fig. 1 and gives a good idea of its arrangement. A 2-hp. motor is seen at the extreme left belted to a small dynamo which furnishes low voltage current for the process. There are five vats arranged in cascade. Each vat contains four anodes and five cathodes arranged in multiple. The vats are fifteen inches long, seven inches wide and twelve inches deep on the inside. The surface of each electrode submerged in the electrolyte is six inches square.

A vertical section of one of the vats is shown in Fig. 2 and a composite plan and horizontal section is shown in Fig. 3. Both these sketches are to some extent self-explanatory.

It will be noted in Figs. 2 and 3 that the ends of the vats are of slate grooved to receive the slate bottom and the glass sides. The parts are cemented together with litharge and glycerine and held firmly in place by steel tie rods, of which there are two on each side. Each vat has a lead overflow spout on one end and a lead spout in one corner of the bottom for cleaning out the anode mud. The bottom spout is kept closed by a rubber stopper.

Copper rods $\frac{1}{4}$ inch in diameter serve as bus bars. These are held on the upper edges of the glass sides by means of a spring clamp at each end. Shallow cross grooves are filed in each bar $1\frac{1}{2}$ inches apart to keep the electrodes properly spaced.

The electrodes are riveted to strips of sheet copper, which are passed over and soldered to $\frac{5}{16}$-inch copper supporting rods. This is shown in the electrode drawing Fig. 4. A piece of rubber tubing is slipped over one end of each support bar to insulate it from one of the bus bars. By this method the bus bar on one side of the vat will have contact with all the anodes and be insulated from the cathodes while the reverse condition will prevail on the opposite side of the vat.

The cathode bus bar of one vat connects with the anode bus bar of the next vat, etc.

The electrolyte overflows through a lead spout from the upper vat into a lead pipe, which conducts it to near the bottom of the next vat. In a similar way it passes through the five depositing vats to a sixth vat, from which it is siphoned to the well of a Pohle air lift delivering to the upper vat. The rate of circulation can be varied at will by adjusting the air lift.

In the class work it is customary to operate the plant at ten to fifteen amperes per square foot of cathode surface and two-tenths to four-tenths volt between electrodes. No attempt has been made to heat the electrolyte, but this could probably be done if desired. The vats have been used only for depositing copper, but there is no apparent reason why they could not be utilized for work on other metals.

The only difficulty encountered thus far has been the tendency of the acid to eat the slate at the surface of the electrolyte. This has been prevented by coating with acidproof paint.

In operating the plant the students make all necessary electrical observations, weigh the cathodes before and after the test, sample the electrolyte before and after the test, note the rise in temperature of the electrolyte, etc. At the close of the test the electrolyte is siphoned into glass carboys and the anode mud cleaned out, dried and weighed. After the necessary analyses an account of stock of copper, arsenic and precious metals is made, the electrical efficiency calculated and a neostyle sheet prepared giving in tabulated form all data and calculations.

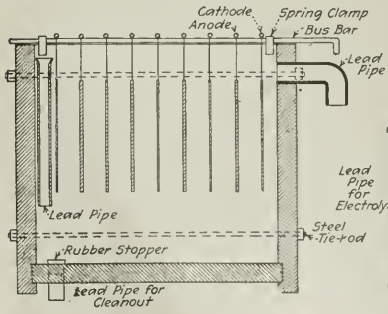


FIG. 2. VERTICAL SECTION OF VAT

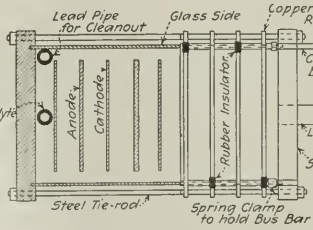


FIG. 3. COMPOSITE SECTION AND PLAN OF VAT

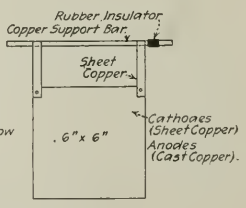


FIG. 4. ELECTRODE

Fuel Economy in the Boiler House—II

A Description of the Types of CO_2 Recorders Used in America and Europe and Principles Involved in Their Operation—Sarco, Uehling, Simmance & Abady, Cambridge Bi-Meter, Auto and Mono-Recording Instruments

By JOHN B. C. KERSHAW

In the previous article[1] the writer showed how important was regular and systematic testing of the waste gases from boiler plants, in connection with the urgent need for economy in the use of fuel, and also pointed out that automatic gas-testing apparatus could be of great service in assisting the boiler engineer to obtain the highest possible efficiency from his plant. The best method of connecting the testing apparatus to the boilers and flues was then described, and the need for placing the apparatus in charge of a properly trained man was emphasized. Corroboration of the remarks which the writer made on this subject of skilled supervision is found in an article which was published in an English technical journal before the war by a power station engineer, under the title of "CO_2 Recorders in Power Stations." This correspondent pointed out that many of the failures of automatic gas-testing apparatus in the past had been due chiefly to the defects in the installation and management of these machines, rather than the fundamental defects in their design. The advantages of the recording type of apparatus were stated to be:

"(1) That it shows at any and all times the percentage of CO_2 being obtained, so giving a guide to engineers in charge and firemen as to the conditions prevailing in the furnaces; (2) it is an index to the correct thickness of fire under different conditions; (3) it is a guide as to the correct amount of draught to be given to the fires under varying conditions; (4) it is an index of any air leakage at all points between the furnaces and the position in the flues where the gas for analysis is taken from."

The writer is aware that the U. S. Bureau of Mines has published two valuable bulletins, Nos. 91 and 97, dealing with "Sampling of Flue Gases" and "Automatic CO_2 Recorders." He has made some use of the latter bulletin in compiling the descriptions given below, but only five recording types of instruments were tested by Messrs. Barkley and Flagg in their investigations, and are described in Bulletin 91, whereas double this number are on the market and have been used in Europe and America. Since no independent description of the various types of CO_2 recorder has yet been published in this journal, the writer has thought it well to collect in one article the available information on the subject, and below all the leading types of automatic gas testing and recording apparatus are illustrated and described, with notes upon their respective advantages and defects.

The "Ados" or Sarco recorder is the oldest and most widely used form of testing apparatus for obtaining continuous and regular records of the CO_2 contents of the waste gases. Fig. 1 shows the latest form of the Sarco recorder. The power for actuating the instrument is supplied by a fine stream of water with a head of about two feet which enters the tube shown on the right hand side of the figure. The rate of flow, and therefore of operation, can be varied by altering the size of the jet used for the small glass injector. The water admitted gradually fills the measuring vessel shown in the center of the figure, and when it reaches a fixed point on the tube connecting this vessel to the gas supply, the water is automatically siphoned out, and 100 cc. of the gas to be tested are drawn into the vessel. This gas, as the water again rises in the measuring vessel, is forced into the solution of caustic potash (sp. gr. 1.27) contained in the large vessel shown on the left hand bottom corner of the figure, and as the gas bubbles up through this solution, any carbon dioxide contained in it is absorbed. The residual gas now passes up into two tubes containing floats, placed directly above the absorption vessel, and by suitable

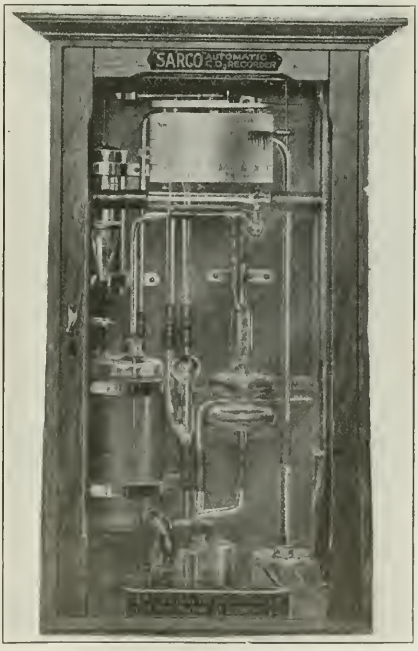


FIG. 1. THE SARCO CO_2 RECORDER

[1] CHEMICAL & METALLURGICAL ENGINEERING, Vol. 20, No. 4, Feb. 15, 1918.

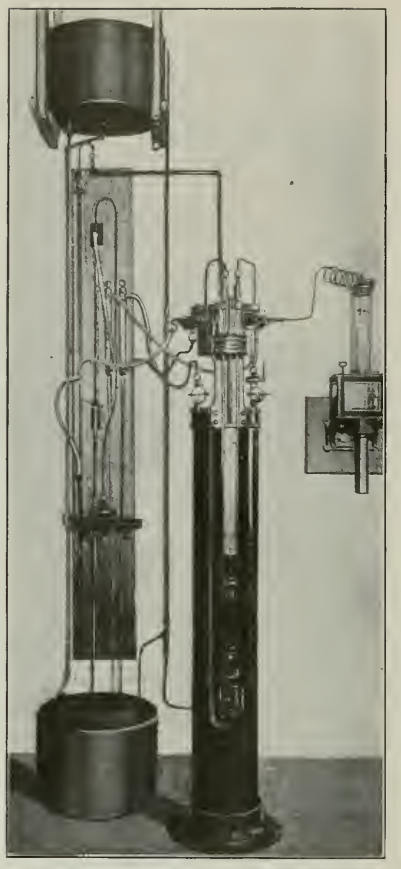


FIG. 2. THE UEHLING GAS COMPOSIMETER

mechanism records are obtained, on the paper attached to the revolving drum, of the volume of the residual gas.

It is customary to arrange the controlling mechanism so that samples are drawn from the flue at intervals of ten minutes, and the KOH solution requires renewal according to the frequency of the tests made.

The Uehling Continuous Gas Composimeter

The Uehling gas-testing instrument is based upon the law which governs the flow of gas through small apertures. The gas-containing vessels of different capacities are placed in connection with a steam-jet aspirator and with the flue. The apertures connecting the smaller vessel with the other, and the second or larger vessel with the flue, are small and of equal size. When the aspirator is set to work, a partial vacuum is produced in both vessels, consequent upon the fact that gas is being drawn out of them more quickly than it can enter, and the vacuum as measured by manometers attached to each vessel is found to be twice as great in the smaller as in the larger vessel. If now the gas passing through the larger vessel be submitted to the action of a solvent which absorbs and withdraws one of its constituents, the vacuum in the second chamber or vessel will be increased and the difference between the partial vacuum in the two vessels will be diminished in like ratio. The absorption of CO_2 from furnace gases by caustic potash can therefore be utilized to cause differences in the pressure ratio in the two gas vessels, and by proper calibration a means for ascertaining the percentage of CO_2 in the gases is obtained.

To embody this principle in a practical apparatus the following conditions must be fulfilled: (1) The gas must be brought into the apparatus under a constant tension, and must be drawn through the two apertures with a continuous and uniform suction. (2) Both apertures must be located in a part of the apparatus which is maintained at a constant temperature. (3) Provision must be made for keeping these apertures perfectly clean. (4) The larger chamber must be made perfectly gas-tight. (5) The constituent to be absorbed (CO_2) must be entirely removed while the gas is passing through this part of the apparatus.

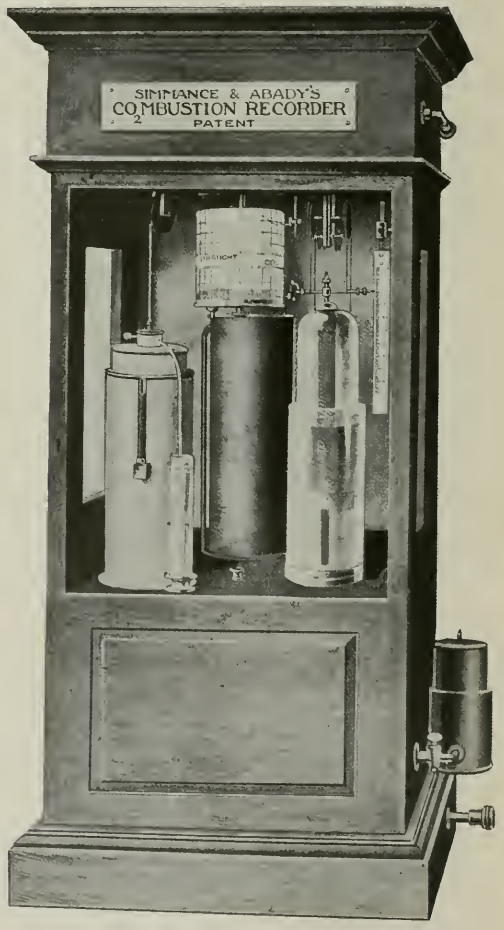


FIG. 3. THE SIMMANCE & ABADY CO_2 RECORDER

The Uehling instrument is made in two forms, the first with, and the second without, a recording pen and drum. Fig. 2 illustrates the latter type.

The Simmance-Abady Recorder

The Simmance-Abady recorder is illustrated in Fig. 3, and in some of its features resembles the "Sarco" apparatus, for water supplies the motive power and the CO_2 is absorbed by bubbling through a solution of caus-

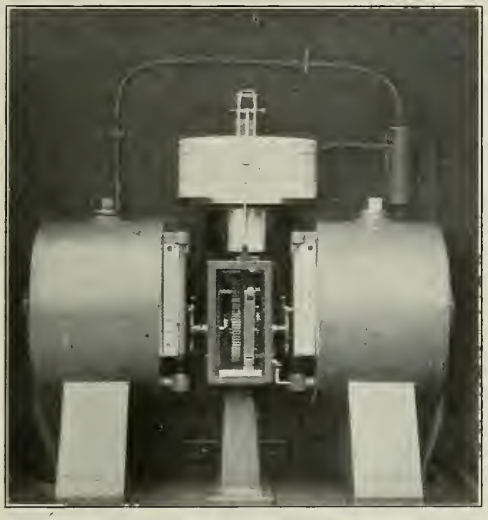


FIG. 4. THE CAMBRIDGE BI-METER CO_2 RECORDER

tic potash, contained in a steel vessel enclosed in the lower portion of the case which contains the apparatus. About 600 cc. of the flue gases are drawn from the flue at definite intervals of time, and a measured portion of this volume is employed for each test in that portion of the apparatus called the "analyzer." When the flue gas has been transferred from the "extractor" into the "analyzer," the CO_2 is absorbed, and owing to such absorption the analyzer bell will not rise to its full height. It is allowed to work automatically and to rise as far as it will, where it remains for a few seconds and then drops a little, as the heat of the chemical combination disperses and the absorption is completed. At this point a pen descends, and marks downward from the zero on the chart to the position of the analyzer bell.

A boxwood scale on the side of the recorder tank is graduated to show 100 per cent CO_2 at the bottom and 0 per cent at the top. The capacity of the bell shown on the left in the figure is such that when the test is made with air the whole of the sample is transferred to the recorder bell on the right, which then rises to the zero point on the scale. When a sample of flue gas is admitted into the appa- extractor bell through the analyzer vessel into the recording bell, but owing to the absorption of CO_2, this bell does not rise up to its full height, and the deficiency is registered by the fall of the pen to the point reached by the top of the tank. The bell then discharges its residual gas, and sinks to its original position in readiness for a new charge of gas, minus its CO_2 contents.

The Bi-meter CO_2 Recorder

The principle upon which the Bi-meter CO_2 recorder is based is that of measuring the flue gas, before and after the absorption of CO_2, by two ordinary gas meters, the actual absorption occurring in a vessel containing caustic lime, and the temperature of the gas before and after absorption being controlled by water cooling, in order to eliminate errors due to the difference in volume caused by temperature changes. Fig. 4 shows the appearance of the instrument. The gas is drawn through the apparatus by means of an aspirator, and the difference between the speeds of the two gas meters provides a measure of the amount of CO_2 in the gas. These meters are connected by a differential gearing to the mechanism that actuates the recording pen. After a certain definite volume of gas has passed through the first meter, the pen is made to drop to its initial position, from which it starts to rise again at a speed dependent on the proportion of CO_2 absorbed. The maximum number of tests per hour possible with this type of recorder is 25, and the number can be lowered by reducing the volume of gas passing through the meters. The record chart for 24 hours is 15 inches long, and the drum carrying it is seen in the center of the figure.

The Auto-Recorder

The auto-recorder is shown in diagrammatic form in Fig. 5 and, like the two first described, the instrument depends upon a stream of water for its motive power

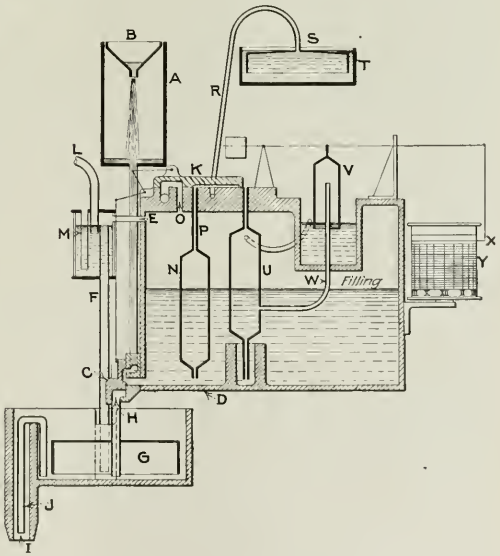


FIG. 5. THE AUTO-RECORDER

and upon caustic potash as the absorption chemical. The water enters the apparatus by the funnel *B*, and passes down into the large vessel *D* through the sliding valve at *C*. When the chamber *D* is quite filled with water.

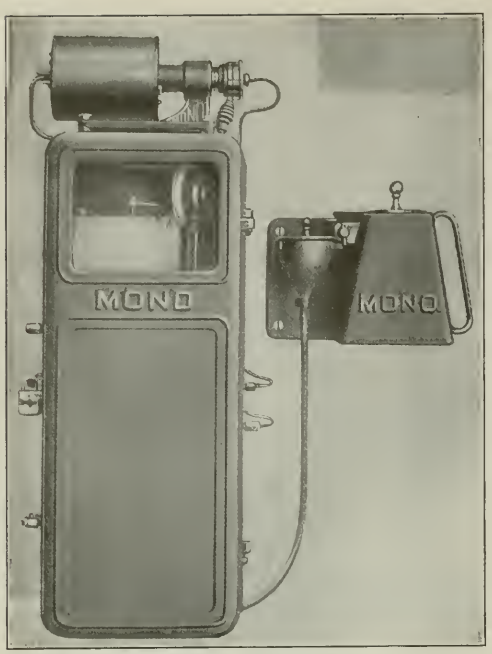


FIG. 6. THE MONO AUTOMATIC CO_2 AND CO RECORDER

this overflows by the pipe *E* into the vessel *M* and thence into the lower vessel containing the float *G*, and the consequent rising of this float causes two motions which start and carry forward the testing operation. In the first place, the float as it rises pushes up the valve *C* and closes the water supply at this point, at the same time opening the passage *H*, by which the water escapes from *D* and draws in a sample of the flue gas through *E* and *I*. In the second place, the rising of the float *G* causes the sliding valve at *K* to move to the right, and puts the measuring vessel *N* into communication with the tank *D*, through the passage *O*, so that a sample of the gas passing into *D* is also drawn into *N* as the water sinks. When the tank *D* is quite emptied, the siphon at *J* comes into operation, and, by discharging the water from the lower tank, causes the float *G* to fall and the valves *C* and *K* to return to their first positions. *D* and *N* therefore are now slowly filled again with water, and the surplus gas in the former is forced out into the atmosphere, while the measured volume in *N* is forced up through the pipe *R* into the absorbing tank *T*, where it collects under the bell *S*, and is speedily deprived of its CO_2 by the caustic potash solution contained in this tank. When the tank *D* again overflows and the discharge of the water again causes the movement of the sliding valve at *K*, the residual gas under *S* is drawn through *R* into the second measuring vessel *U*, and any deficiency of gas required to fill *U* (due to the absorption of CO_2) is made up by withdrawal from that contained in the bell *V*, suspended from a weighted lever to which is attached the recording pen at *X*. The downward movement of this lever after each test is completed therefore gives a measure of the percentage of CO_2 in each sample of gas drawn into *N*, and is recorded on the clockwork drum chart shown at *Y*.

The Mono Recorder

The Mono recorder differs from those previously described in the fact that it is a combination CO_2 and O recorder and may be used for either gas, while by the addition of a further appurtenance it is possible to make the instrument record the percentage of carbon monoxide. The power which actuates the mechanism of the instrument is derived either from compressed air or water, mercury being employed in the measuring portions of the apparatus, where the gases come into contact with the fluid medium. The gas, after being cooled and measured, is deprived of its CO_2 by bubbling through a caustic potash solution contained in the tank, shown in Fig. 6. The residual gas then passes up into the measuring bell, which actuates the recording mechanism, precisely as in the Sarco and Simmance-Abady instruments.

When it is desired to record oxygen, the gas stream is made to pass through an electric oven fixed on the top of the instrument, in which the oxygen is brought into contact with heater carbon, with formation of CO_2 in equivalent amount. The gas issuing from the oven is then cooled and passed through the remainder of the apparatus as before, the difference of the two

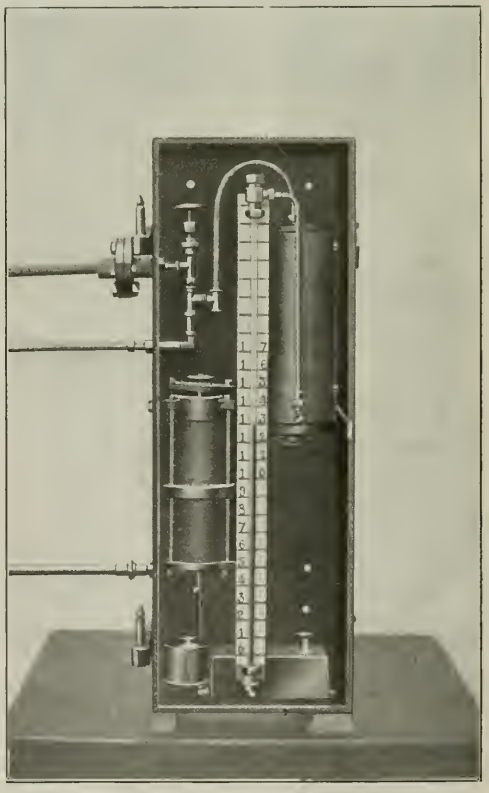


FIG. 7. THE WEBSTER W. R. COMBUSTION INDICATOR

consecutive tests giving the percentage of oxygen contained in the gas. Carbon monoxide is determined in the same manner. This method of estimating the oxygen and carbon monoxide, however, is dependent upon there being no other gases present which will combine with carbon at a red heat, and a mixture containing hydrocarbon gases, carbon monoxide, carbon dioxide and oxygen cannot therefore be analyzed in this manner.

The Webster W. R. Combustion Indicator

As its name implies, the Webster W. R. combustion indicator is not a recording apparatus, but gives a continuous reading of the CO_2 present in the boiler or chimney gases. Fig. 7 is a diagram illustrating the principle upon which this CO_2 indicator works. A water or steam aspirator (on the left) draws the flue gas continuously through the instrument, and after passing through the filter the gas enters a chamber containing a porous pot charged with a solid absorbing medium, for CO_2 gas. This chamber and pot are connected, as shown, by two vertical pipes, or tubes, with a vessel containing water, and the difference in pressure between the gas in the outer chamber and that inside the pot, due to the absorption of CO_2, causes the water to rise in the pipe that connects the porous pot with the water tank. By aid of a graduated scale attached to the latter pipe, the percentage of CO_2 can be read off directly, $\frac{3}{8}$ of an inch in height being taken as equal to 1 per cent CO_2. The "indicator" is said to respond quickly to any changes in the composition of the flue gases, and if placed in a position where the fireman can see the fluctuations of the water column, it provides him with a useful help to the efficient control of his fires. The cartridge containing the solid absorbent is said to require renewal only every other day, but the period for which it will act efficiently depends, of course, upon the CO_2 contents of the waste gases.

Eliminating Phosphorus and Sulphur in Electric Ferromanganese Furnaces

By Jay Lonergan

IN HIS discussion of the paper of Robert M. Keeney, presented at the Colorado Meeting of the American Institute of Mining Engineers, H. W. Gillett mentions the fact that recent experiments have indicated that it may be possible to eliminate a large proportion of the phosphorus from high-phosphorus manganese ores. It is thought that it would be interesting to the producers of ferromanganese to have published the methods which have been tested, and in this respect the following notes may be of value.

When the first furnace of the Iron Mountain Alloy Co. was started an attempt was made to smelt a high-phosphorus ore by carrying an excess of lime. This run lasted several days and was a failure. The ore contained about 0.32 per cent phosphorus, and the resulting ferromanganese about 0.6 per cent phosphorus. After this trial, all high-phosphorus ore was mixed with sufficient low-phosphorus ore to give a charge with a phosphorus content of about 0.15 per cent. With a mix of this nature no trouble was experienced in keeping the phosphorus content of the ferromanganese under 0.25 per cent, the maximum limit set by consumers.

A test has just been completed, however, which had the object of determining the proportion of both phosphorus and sulphur which can be eliminated by ordinary practice. This test will partially answer Mr. Gillett and others interested in such questions. The results are given in Tables I and II. Table I gives the analysis and make-up of the charge used, while Table II gives the resulting products from this run. Column 7, Table II, shows that 52.6 per cent of the phosphorus is retained by the metal, while the unaccounted losses (obtained by difference) show that 31.4 per cent is carried off through the ventilators.

While no tests have been made to determine the proportion of mechanical and volatilization losses, from observation I should say that the greater part is a purely mechanical loss, therefore the phosphorus in the dust is still retained in its original form. In case the phosphorus were volatilized it would probably indicate its presence by PH_3 gas, poisoning some of the furnace men. To date there have been no cases of poisoning.

Using the results of the above test and determining the maximum allowable percentage of phosphorus in a manganese ore to produce a metal containing a maximum of 0.25 per cent phosphorus, it took 2830 lb. dry ore to make 1000 lb. ferromanganese. On the basis that 52.6 per cent of the total phosphorus charged will go with the metal, no more than $4\frac{3}{4}$ lb. phosphorus can be carried in 2830 lb. ore and about 1760 lb. coal and lime.

Assuming that the latter contains 0.34 lb. phosphorus, the ore can contain 0.17 per cent. This figure is substantiated by the results of several months' run of the furnace previously mentioned.

Column 4, Table II, shows that at least 98 per cent of the sulphur in the charge is eliminated.

Iron Mountain Alloy Co.,
Denver, Colo.

TABLE I. FURNACE CHARGE

	1 Weight in Lb.	2 Per Cent. S.	3 Lb. S.	4 Per Cent. P.	5 Lb. P.
Lot 305 ore	5,000	0.081	3.847	0.023	1.092
Lot 314 ore	5,000	0.111	5.272	0.015	0.712
Lot 220 ore	20,000	0.245	44.100	0.036	6.480
Lignite coal	11,812	0.398	47.011	0.004	0.472
Lime rock	5,500	0.046	2.530	0.050	2.750
Total			102.760		11 506

TABLE II. FURNACE PRODUCTS

	1	2	3	4	5	6	7
		Sulphur			Phosphorus		
	Weight in Lb.	Analysis per Cent. S.	Weight Lb. S.	Per Cent. of Total Charged	Analysis per Cent. P.	Weight Lb. P.	Per Cent. of Total Charged
Metal	9,828	0.012	1.179	1.148	0.056	5.503	52.6
Slag	12,137	0.293	35.561	34 60	0.014	1.699	14.75
Dirty metal and slag	2,490	0.200	4.980	4.75	0.028	0.697	6.06
Unaccounted for in dust and volatilization. Losses (by difference)			61.04	59.40		3.607	31.40

Determining Zero Reading on an Ellison Gage

By Herman Bacharach

In the September 1 issue of Chemical & Metallurgical Engineering is a very interesting article by Mr. Evald Anderson on a method of determining the zero reading of an Ellison gage without disconnecting it. The necessity of making this determination is clearly explained and the method is, no doubt, a very good one for portable instruments, but in a permanent installation

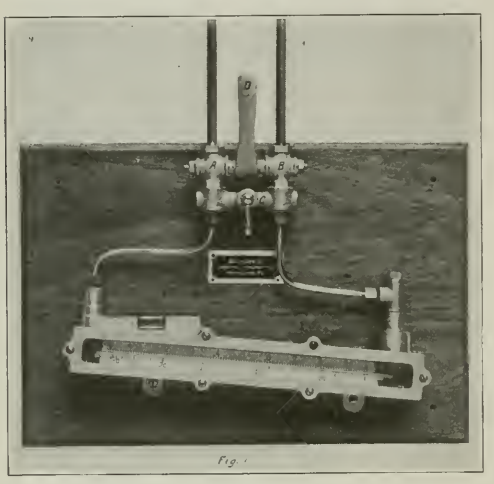


FIG. 1. GAGE READY TO ATTACH THE PRESSURE LEADS

it might be well to make provision for getting the zero reading at any time by using the proper valve and pipe connections instead of rubber tubing and a clamp.

It would probably interest your readers to know of an instrument comprising a gage properly connected and mounted on a board ready to attach the pressure leads, as shown in Fig. 1.

The valves *A* and *B*, Fig. 1, are closed simultaneously by lever *D*, and cock *C* is then opened. The oil will then come to rest at the zero position. After this position is noted, the valves *A* and *B* are opened and cock *C* closed, thus placing the gage in operation. Since the two pressure leads are closed when the zero position is being determined, there is no danger of the differential pressure having any influence on the reading and also, since the operation of these valves is simultaneous, the liquid will not be forced out of the gage. The gage may be calibrated to read velocity or volume.

Fig. 2 shows a scheme of connections where several differential pressures are to be determined. Gages may be used as shown and placed where they may be easily seen by the operators. A recording instrument can be placed anywhere near, perhaps in the superintendent's office, and any one of the differential pressures recorded by the proper arrangement of the link valves *V*. The zero reading of the gages can be taken as described above, Fig. 1.

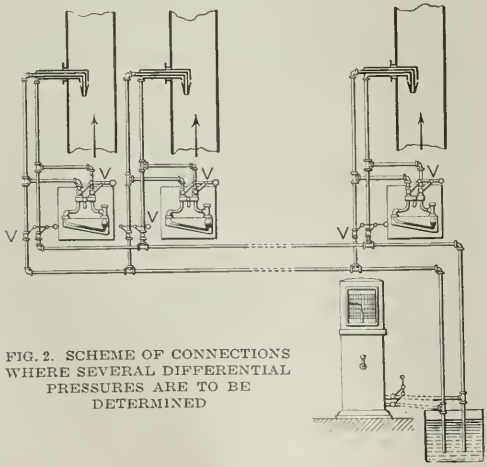


FIG. 2. SCHEME OF CONNECTIONS WHERE SEVERAL DIFFERENTIAL PRESSURES ARE TO BE DETERMINED

Points in Pump Selection*

By B. N. Everett

PUMPS as a rule have very high load factors; that is, ratio of power consumed to maximum demand is high. Also, the power consumption per dollar invested in the apparatus is higher than in most other power-consuming equipment. It would appear, therefore, that the matter of power consumption should be given consideration, especially when the variation of power requirements of different pumping arrangements is so great.

The fact that exhaust steam from direct-acting pumps may often be used to heat feed water has led to the habit of assuming that steam economy is of little importance. But which is the better economy—to use efficient pumps and let water enter the boilers considerably below the boiling point at times; or to allow heat to escape to the atmosphere because of an excess of exhaust steam from inefficient pumps? In the first case the deficiency in feed temperature must be made up by fuel and in the second case fuel is burned to generate the steam that passes through the pumps and heats the feed water and also the steam going to waste.

The word "efficiency" as ordinarily applied to pumps is of little value. For instance, a steam pump with an efficiency of 80 per cent (that is, the indicated horsepower of the water end is 80 per cent of the indicated horsepower of the steam end) was replaced with an electrically driven triplex pump with an over-all efficiency of 70 per cent (that is, the water horsepower was 70 per cent of the horsepower supplied to the motor). The electric pump was driven through the medium of an efficient engine and generator and required only 6 lb. of fuel per 1000 gal. pumped, whereas the steam pump required 42 lb. of fuel per 1000 gal. pumped, which is a difference of several hundred per cent. In this particular case besides the reduction in fuel consumption one man's labor was saved, as the steam was supplied from a separately fired boiler.

The accompanying chart gives the principal points to be considered by an engineer in selecting a pump. No one but an engineer with a knowledge of various classes of pumping machinery and all the individual

*Power, Sept. 24, 1918.

requirements of the plant should handle the matter. The various items are so interdependent that all must be borne in mind while each is considered individually.

The character of the liquid to be pumped has a direct bearing on the size of pipe to use, the advisable speed, the suction lift of the pump and the power required.

CHART SHOWING POINTS TO BE CONSIDERED IN THE SELECTION OF A PUMP

- Liquid to be pumped...
  - Specific gravity
  - Temperature
  - Viscosity
  - Size and nature of solids
- Total head.....
  - Suction lift or head.....
    - Size of pipe
    - Vertical distance
    - Suction-pipe friction
  - Discharge head.....
    - Size of pipe
    - Vertical distance
    - Discharge-pipe friction
- Capacity.....
  - Maximum demand
  - Average demand
  - Storage capacity
  - Breakdown service
  - Hours service per day or per year
  - Advisable speed
  - Source of liquid
- Power.....
  - Available
  - Time of operation
  - Reliability
  - Required
  - Control
  - Estimated cost.....
    - Per 1000 gallons
    - Per month or year
    - Compared to investment
- Cost....
  - Initial
    - Pump
    - Driver
    - Piping
    - Installation.....
      - Location
      - Space required
  - Operating..
    - Labor
    - Power.....
      - Use of exhaust steam
      - Efficiency
      - Transmission losses
      - Cost per 1000 gallons pumped
      - Cost per day or year
      - Fuel consumption
    - Fixed charges

Hot water must flow to the pump under a head. Pumps handling sewage, sand, etc., need special features.

In deciding on the size of pipe to use, each of the following should be considered: Liquid to be pumped, total friction head of pipe and fittings, maximum capacity, average demand, hours service per day, per year, etc., and cost of power. It is a problem of balancing the cost of power consumed to overcome friction against the cost of the line installed. It is somewhat analogous to figuring the size of an electric transmission line. It requires power to overcome friction in proportion to the amount of liquid pumped and the extra first cost of a larger size of pipe will often be returned in saving in power in a short time.

Some time ago data sheets giving the friction of water flowing through pipes and elbows were revised by pump manufacturers because they did not agree with practice. Pipes soon get scaled up inside and offer more resistance than when new.

When a pump is pumping to a system direct, without any storage provided, it must be large enough to meet the maximum demand. Care should be taken that no loss of time is incurred through lack of pump capacity. A woolen mill had a number of machines that required filling with liquid periodically. They were served by a pump that required ten minutes at each filling. It was shown that the output could be increased by reducing this period to two minutes. A pump of the required capacity would have five times the displacement of the old pump, which was of ample capacity to supply the average demand of all machines. So, by installing a storage tank of a capacity to meet the maximum demand the filling period was reduced to less than two minutes. Besides, power was saved by reducing the many starting and stopping periods.

Sometimes two pumps can show better economy than one. A manufacturing plant was using water for all services by pumping from artesian wells to a tower tank under a total head of 120 ft., and the water requirements had outgrown the capacity of the pump. Approximately half of the water was used for cooling gas engines and air compressors in the power plant, for which service a head of 30 ft. was ample. A separate pump and control tank were installed and the power required to pump water was reduced 30 per cent, at the same time increasing the pumping capacity for future requirements.

The calculations of the actual power consumption of a pump should include all the power used or necessarily wasted. The heat lost by radiation and valve leakage in keeping a pipe line and steam pump warm and ready for service often amounts to considerable per 1000 gal. pumped. A belted triplex pump, even with an efficiency of 80 per cent, if controlled by a bypass valve, may be consuming power at its maximum rate and actually delivering only a small percentage of its capacity.

As a general rule direct-acting steam pumps should be employed only where use of all the exhaust steam is possible, or where service is intermittent and better economy will not warrant a larger investment. Steam-valve leakage often amounts to an enormous total, and pump slippage is often a more formidable loss than is suspected. Consider a direct-acting steam pump supplying an average demand equal to 30 per cent of the normal capacity of the pump, pump slippage at normal rate amounts to 15 per cent, and the pump is controlled by a throttling type pressure control valve. Then the slippage (15 per cent of capacity) amounts to 50 per cent of the discharge (30 per cent of capacity) and the steam consumption due to slippage is 50 per cent instead of merely 15 per cent. Under these conditions also the radiation losses and valve leakage amount to more per 1000 gal. pumped. So it is often the case that the power consumption per 1000 gal. pumped is more than double what would be indicated at a normal speed.

Tilting pumping traps are used extensively in handling condensation and feeding boilers, and very low steam consumptions are obtained when pumping hot water. Tests showing steam consumption when pumping cold water would be interesting.

In a certain plant that used a great number of steam pumps, serving evaporators, washers, coolers, etc., the pumps were allowed to run without oil and at destructive speeds and abused generally. Production was interrupted almost daily in one department or another by pump trouble and the pump repairman's hair was gray. The chief engineer said that although he could use the exhaust from the pumps, he was installing single-stage centrifugal pumps direct-connected to electric motors in every case where they could be applied, simply because they are more fool-proof and increase the factor of safety against interruption of service.

In the case of centrifugals even greater care should be taken in making the application, especially in regard to the correlation of total head and peripheral speed of impeller to the motor speed, and the means of regulating capacity.

Recent Chemical and Metallurgical Patents

Magnesian Furnace Refractories

Magnesium Oxide from Dolomitic Rock.—A. M. MITCHELL of Tuckahoe, N. Y., patents a process of separating magnesium oxide to be used in the manufacture of refractories from mixtures of magnesium and calcium carbonates commonly called dolomitic rock. The ground rock is charged into a tube mill, set into a furnace and heated externally to about 950 deg. F., at which the CO_2 is driven off from $MgCO_3$, but which is too low to decompose the $CaCO_3$. During calcination the material is finely ground, thus separating the minute particles of magnesite and calcite. After calcination the calcite remains in its original shape, crystalline and compact, while the magnesite has been converted into MgO, which is powdery and light. Separation of these two materials may then be effected by well-known gravity concentrators. (1,273,110; assigned to Mitchell & Grenelle; July 16, 1918.)

Furnace Lining.—S. R. NEWBERRY of Cleveland, Ohio, patents the following method of burning dolomitic limestone in order to prepare a refractory material which will not air-slack. He takes a dolomitic limestone as free as possible from silica, and wet-grinds to 100 mesh together with from 2 to 5 per cent of bauxite, iron ore or some substance containing oxides of the aluminium-iron group. These amphoteric bases form very fusible compounds with the lime, and but a small percentage is required to properly "fix" the lime so that it will not form hydrates. The slurry is burned at from 2700 to 3000 deg. F. in a cement kiln, the temperature depending upon the nature and quantity of the addition, and the resulting clinker crushed to required size for sale or for the formation of refractory brick. (1,267,686; May 28, 1918.)

J. O. HANDY and R. M. ISHAM of Pittsburgh, Pa., produce a furnace lining material from dolomitic or magnesian limestones in somewhat the same manner. Their fluxing agent is calcium chloride, or in case the material is nearly pure MgO, magnesium chloride is better. Preferably the crude material, crushed to 20 mesh, is mixed with sufficient brine or bittern so that the dried material will contain about 10 per cent of the chloride. This is then dried to a coherent mass and burned in a rotary kiln at 1500 deg. C. During this operation the chloride decomposes if sufficient water vapor is present from the products of fuel combustion or otherwise and forms hydrochloric acid which passes off with the furnace gases. The resulting clinker contains but fractional percentages of chlorine, and is available for making furnace linings or refractory bricks. (1,270,818; assigned to A. S. Davison Co.; July 2, 1918.)

Artificial Magnesite.—J. O. HANDY and R. M. ISHAM of Pittsburgh, Pa., prepare an artificial magnesite claimed to have the desirable refractory qualities of imported crude magnesites. They calcine a dolomite in a rotary kiln so as to remove all the carbon dioxide without "dead burning." The calcine, granulated to the size of a pea, is leached with cold water to remove the calcium oxide down to from 3 to 10 per cent. Additions of basic slags and clays are then made and the material is re-burned at 1550 deg. C. to remove the water of hydration and carbon dioxide. The final product should have 85 to 88 per cent MgO, lime 3 to 10 per cent, silica 4 to 8 per cent and a little iron and alumina. The small amount of lime is necessary for bonding, yet is so small that danger from slacking is absent. (1,270,819; assigned to A. S. Davison Co.; July 2, 1918.)

High-speed Steel Substitutes.—P. R. KUEHNRICH of Sheffield, Eng., notes that cobalt has been used as an ingredient of many alloy steels and that carbon-chromium steels are known to be much superior to plain carbon steel tools, although they do not possess the quality of red-hardness until cobalt is added, which fact constitutes his invention. He recommends a composition approximating

C	1.5 per cent
Cr	12.0 per cent
Co	3.5 per cent
Si	0.3 per cent
Mn	0.2 per cent

with up to 1 per cent of any of the other metals of the chromium group. (1,277,431; Sept. 3, 1918.) G. L. KELLEY and A. H. MILLER of Germantown and Ambler, Pa., claim especial toughness as well as hardness by the addition to nickel of from 0.5 to 2 per cent of zirconium, which is less than previously recommended, when accompanied by aluminium and silicon. The sum of the last two ingredients should be at least 8 per cent; they are equivalent to a certain extent, but the content of aluminium or silicon should not fall below 2 per cent or go above 8 per cent. (1,258,227; Mar. 5, 1918; assigned to Midvale Steel Co.) H. S. COOPER of Cleveland, Ohio, patents a composition very similar to the above. He presents diagrams showing that at least 10 per cent aluminium must be added to nickel to give a scleroscopic hardness greater than 55, which is necessary for a cutting tool. More aluminium, while increasing the hardness, cuts down the already deficient toughness. Another diagram shows that if 2 or 3 per cent silicon be added to the Al-Ni alloy, the hardness is still sufficient, while the grain is finer, and the toughness increased. Adding from 1 to 15 per cent zirconium to the ternary alloy gives the mixture red-hardness and great toughness and forms an excellent cutting tool. Chromium group metals may be added to the quaternary alloy with advantage—tungsten especially increases the life of the tool. These alloys melt at a low temperature and can be cast to shape and ground into a tool. No heat treatment is required. The alumino-thermic method of reduction of the constituent oxides is recommended for the production of the pig metal. (1,227,046, Aug. 27, 1918, and 1,278,304, Sept. 10, 1918; assigned to the General Alloys Co.)

Manufacture of Acetic Acid.—HENRY DREYFUS of Basel, Switzerland, patents processes of making acetic acid, which comprise passing a mixture of acetaldehyde and oxygen over a catalyst at a temperature between the boiling point of acetic acid and 400 deg. C. (1,286,255-1,286,256).

Ferro-molybdenum Manufacture.—E. H. WESTLING and CARL ANDERSON of San Francisco patent the process of making ferro-molybdenum from ferric molybdate by reducing the latter with carbon or hydrogen at a comparatively low temperature (less than 900 deg. C.), producing a spongy product which does not oxidize easily, and which is assimilated in a steel bath with the utmost facility. The ferric molybdates may be precipitated from soluble alkaline molybdates by ferric sulphate or from soluble molybdenum salts by the same reagent after neutralizing the solution with alkaline carbonates. With a minimum of iron, a yellow $Fe_2(MoO_4)_3$ is formed, while with excess a brown $Fe_2O_3 . MoO_3$ results. By properly mixing the two a ferro with any desired composition between the limits may be produced. (1,278,408; Sept. 10, 1918.)

Ferro-phosphorus and Cupro-phosphorus.—H. A. WEBSTER of Columbia, Tenn., finds that if a proper mixture of iron phosphate, coke and limestone is heated to from 1000 to 1500 deg. C. in a rotary kiln, the interior of the furnace becomes lined with incandescent carbon which materially hastens the reaction. The products—an iron phosphide containing 25 per cent phosphorus and a slag—may be granulated and separated by a magnetic separator. The gasified phosphorus may be largely retained in the nodular phosphide by charging iron filings with the mixture. The proportion of phosphorus in the compound may be increased to 30 per cent by heating the same mixture in a closed furnace at three atmospheres, cooling the melt under pressure to the liquidus and then tapping the contents. (1,264,236 and 7; April 30, 1918.) L. A. JEFFS of Salt Lake City, Utah, patents the process of making cupro-phosphorus in a furnace similar to the Stassano. He charges phosphate rock, oxidized copper ore and a large excess of carbon, together with the necessary flux. The reduced copper trickles down through incandescent carbon against an upward stream of phosphorus and CO, and the cupro-phosphorus formed collects in the crucible below the slag layer. By using a small percentage of copper the exit gas can be made so rich in phosphorus as to warrant its recovery as the principal product. (1,268,849; June 11, 1918.)

Ferro-silicon.—J. E. JOHNSON, JR., of Hartsdale, N. Y., notes that the large amounts of nitrogen in atmospheric air lowers the maximum temperature in the ordinary blast furnace to a point where a 12 per cent ferro-silicon is the ordinary alloy made. Since the calorific intensity varies approximately inversely as the products of combustion, he claims that the temperature of the focus obtainable with air enriched to 50 per cent oxygen will be high enough so that much larger amounts of silicon will be reduced and a 50 per cent alloy equal to that now produced in electric furnaces will result at a lower cost. Enriched blast will also reduce the cost of the lower grade alloys. (14,547; Reissued Nov. 12, 1918.) GEORGE C. FURNESS of New York notes that the electric shaft furnace with deeply embedded electrodes ordinarily used in commercial production of ferro-alloys requires a charge which at once shall have a low electrical conductivity and a high porosity. In the manufacture of ferro-silicon, which consumes a large proportion of reducing carbon, this material, ordinarily introduced as coke, anthracite or charcoal having a high specific conductivity, tends to short circuit the electrodes along their adjacent sides if charged in sizable lumps. If, however, the carbon is finer, it makes a dense charge which prevents ready escape of the gaseous products of reaction. He therefore patents the use of from 20 to 40 per cent of the total carbon requirements in the form of small-lump bituminous coal, which has a low conductivity and whose evolved gases burning at the top of the shaft minimize the heat losses at that region. (1,284,645; Nov. 12, 1918; assigned to Electro Metallurgical Co.)

Potassium Sulphate From Alunite.—H. F. CHAPPELL of New York City patents the method of separating potassium sulphate from calcined alunite shown in the diagram, Fig. 1. The method depends upon the fact that the sulphate is more than twice as soluble in water at 100 as at 20 deg. C. The boiling solutions in the dissolver are maintained at that temperature by heating make-up liquors in the heat interchanger just after the muffle furnace, as well as by the addition of hot calcine directly into the tank. The filtered hot solutions are passed through a cooling tower against a countercurrent of air, and the crystal bearing mother liquor centrifuged and returned to the dissolver. Evaporation and other losses are made up with wash water from the alumina filter. (1,268,433; assigned to Mineral Products Corporation; June 4, 1918.)

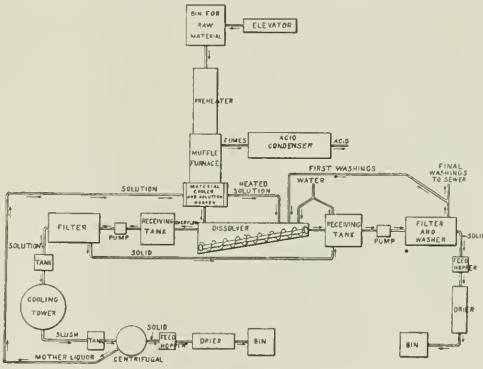


FIG. 1. FLOW SHEET ILLUSTRATING METHOD OF SEPARATING POTASSIUM SULPHATE FROM ALUNITE

Personal

MR. J. CORBUS BUSHNELL, formerly associated with the Business Men's Clearing House, Chicago, Ill., and until recently connected with the U. S. Employment Service as special agent to examine the personnel methods in vogue at Vickers, Ltd., and Woolworth Arsenal, England, has been engaged by the General Engineering Agency, Pittsburgh, Pa., as personnel director.

MR. H. L. GREENE has been appointed chief metallurgist of the Willys-Overland Co. of Toledo, Ohio, and its allied companies.

MR. J. O. LEWIS, superintendent of the petroleum experiment station at Bartlesville, Okla., has just been appointed chief petroleum technologist of the Bureau of Mines, Department of the Interior, in place of MR. CHESTER NARA-

MORE, who has resigned from the Government service to join the Union Petroleum Co., with headquarters at Philadelphia, Pa. Mr. Lewis will be succeeded at Bartlesville by Mr. W. P. DYKEMA, petroleum engineer of the bureau.

MR. SCOTT LINTNER of San Francisco is now manager of the Ray-Broken Hill Mines at Ray, Ariz.

MR. EDWARD A. MILLER has been appointed as assistant superintendent of the Jersey City plant of the Metal & Thermit Corporation, New York, N. Y. Mr. Miller was one of the pioneers in autogeneous welding and cutting, having established the first oxy-acetylene shop in New York City early in 1908 under the corporate form of the Acetylene Welding Co.

MR. JOHN F. NEALIS, who recently received his discharge from the Aero Observers' branch of the service, is now associated with the Powdered Coal Engineering & Equipment Co. of Chicago as advisory engineer. Mr. Nealis formerly had charge of research work for the U. S. Steel Corporation.

MR. D. A. O'CONNELL has been appointed manager of the Seattle office of Marden, Orth & Hastings Corporation.

MAJOR W. P. PUTNAM of the Ordnance Dept., U. S. A., has returned to Detroit to resume his activities as president and general manager of the Detroit Testing Laboratory.

MR. CHARLES F. QUAINTANCE has retired as secretary and sales manager of the Herold China and Pottery Co., Golden, Colo.

MR. W. S. QUIGLEY, president of the Quigley Furnace Specialties Co., Inc., sailed for Liverpool on the Baltic Feb. 15. He will spend several weeks in England, France and Italy.

MESSRS. J. F. SCHOELKOPF, C. P. HUGO SCHOELKOPF and J. F. SCHOELKOPF, JR., have withdrawn as directors of the National Aniline & Chemical Co., New York, N. Y.

MR. C. C. WALLACE, formerly manager of loading of munitions section of the Stenotype Co., Indianapolis, Ind., is now director of development and service, Powdered Coal Engineering & Equipment Co., Chicago, Ill.

MR. FRANK E. WICKS, consulting engineer, recently resigned as superintendent of mills for the Chino Copper Co. at Hurley, N. M., and has opened an office at 404 Union Oil Bldg., Los Angeles, Calif., where he will specialize in concentration and flotation, crushing and fine-grinding problems and plant management.

MR. HARRY W. WOLFF has recently resigned as general manager of the Rector Chemical Corp., N. J., to take charge of the chemical engineering research laboratories of Dr. Alcan Hirsch, New York City.

Obituary

MR. JAMES H. ALEXANDER, for many years one of the vice-presidents of the Standard Oil Co. before its re-organization, died Tuesday, Feb. 18, at his home in Elizabeth, N. J. He was one of the pioneers in the development of the oil industry in the United States and was closely associated in business with John D. and William Rockefeller, H. H. Rogers and the late H. M. Flagler. Mr. Alexander was born in Toronto, Canada, 84 years ago. He is survived by his widow and three sons.

MR. ERNEST L. GODBE, of Salt Lake City, Utah, died at Bath Lake, Calif., Jan. 16. He specialized in chemistry and metallurgy and for many years was engaged in mining in the Pioche, Nev., district, having been vice-president of the Prince Consolidated Mining & Smelting Co. up to a few years ago. He was 51 years old.

MR. FRANK MORRIS BAUM, retired vice-president and general manager of the Portland Wood Pipe Co., who for eight years was State Senator for Spokane County, Washington, died on Feb. 4 in Pasadena, Calif. Mr. Baum was an associate of the gentlemen who are now the controlling factors of the Continental Pipe Mfg. Co. of Seattle and Portland.

Current Market Reports

The Non-Ferrous Metal Market

Friday, Feb. 21.—No response is being made to liberal price concessions, and producers are beginning to curtail production.

Aluminium:—After March 1 aluminium will be on an open market. That prices will go down is evidenced by sales being reported at from 30c. to 32c. per lb., but a rapid return to prewar prices is not expected. Sheets, 18 gage and heavier, are 42c. Powder, 100 mesh, 70c.

Antimony:—Antimony is in light demand and prices have declined to 7¼c. per lb.

Copper:—Copper has been offered as low as 16c. per lb., but there is no immediate consuming demand and buyers are holding off.

Copper sheets, hot-rolled	lb.	$0.24½—$0.34
Copper sheets, cold rolled	lb.	.25½— 23.
Copper bottoWs	lb.	.37 — .33½
Copper rods	lb.	.21½— ....
Copper wire	lb.	.19½— ....
High brass wire and sheets	lb.	.20½— .26½
High brass rods	lb.	.19½— .25½
Low brass wires and sheets	lb.	.22½— .28½
Low brass rods	lb.	.23½— .29½
Brazed brass tubing	lb.	.31½— .37½
Brazed bronze tubing	lb.	.36 — .42½
Seamless copper tubing	lb.	.31 — .37
Seamless bronze tubing	lb.	.31 — ....
Seamless brass tubing	lb.	.30 — .36
Bronze (gold) powder	lb.	1.00 — 1.75

Lead:—Five-cent lead has stimulated buying, with a result that prices have gone up to 5.1 to 5.2c.; Sheets, 8c. lb.

Tin:—The U. S. Steel Products Co. has liquidated over half of its 10,000-ton allotment at 72½c.

Zinc:—Spelter has been steadier than usual, showing only a 50c. drop per ton during the last two weeks. New York spot $134.50 and spring futures $127.50 per ton.

OTHER METALS

Bismuth	lb.	$3.20 — $3.65
Cadmium	lb.	1.40 — ....
Cobalt	lb.	2.50 — 3.50
Magnesium	lb.	1.75 — 2.10
Mercury	75 lb.	85.00 — ....
Mercury	lb.	1.95 — ....
Nickel	lb.	.40 — .45
Tungsten	lb.	Nominal
Iridium	oz.	175.00 — ....
Palladium	oz.	115.00 — ....
Platinum	oz.	100.00 —105.00
Silver	oz.	1.01½— ....

The Iron and Steel Market

Production of steel ingots during January was at the rate of about 41,700,000 gross tons a year, this being about 85 per cent of capacity, which may be estimated at 49,000,000 tons per annum. The January rate was 3.8 per cent under the average rate in November and December and about 10 per cent under the maximum rate ever attained, which was in September, 1918, about 46,800,000 tons.

The rate of production has been declining continuously since just before the Christmas holidays. No close estimate for the month of February can be made, but the monthly report will probably show something in the neighborhood of 75 per cent for the month. The month closes with a rate much below the opening rate.

Mills have operated at widely divergent rates. Some large mills have operated almost full, others ran at 50 to 75 per cent, while a number of small plants have been closed entirely. The divergences are due largely to the character of business the different mills commonly seek, as many small mills depend upon transient orders. This serves them in good stead on a rising market, as they obtain the advantage of price advances more promptly than the mills that book far ahead, but in times like these the policy is disadvantageous.

OPERATIONS IN DETAIL

On the whole, the sheet industry is probably operating at the best rate for any branch of the finished steel trade. The leading interest has been operating at about 80 per cent, while the independents have been doing about 70 per cent. In the case of tin plate there is the curious divergence that the leading interest has been operating at practically 100 per cent in the past fortnight, while the independents have not averaged more than about 50 per cent. The pipe mills show an average of 70 or 75 per cent, doing quite

well in the lap weld departments but rather poorly at butt weld furnaces. Wire mills are averaging 50 to 60 per cent, while plate mills are doing about the same and structural and rail mills are doing hardly anything.

The percentages of finishing capacity in operation as here estimated do not average nearly as high as the estimated percentage of steel production in proportion to steel making capacity, that being due to the simple fact that the finishing capacity of the industry materially exceeds the steel-making capacity, and this is a necessary alignment, otherwise the steel-making departments never could operate in full, as demand could not be expected to be distributed among the different finishing departments in the precise proportions required by their respective capacities.

No Investment Buying

The character of steel demand as shown by the proportions of various finished steel products lately called for is in strict conformity with what would be expected from a scrutiny of the industrial and economic situation. There is demand for steel that enters into common everyday use, while there is practically no demand for steel that enters into construction work. That is to be expected. The investment buyer has not acted. There are scarcely any building projects. The Bridge Builders' and Structural Society reports that the bookings of fabricated steel jobs in January represented 12 per cent of the month's capacity, this breaking the previous low record of 20 per cent, made in November, 1914.

Petroleum is not over-plentiful, the world's prospective requirements are heavy and new wells must continuously be brought in to maintain the country's production, hence it is not strange to find that in the tubular goods industry the most active branch is that of oil country goods. Standard steel pipe, particularly in butt weld sizes, is in very poor request, as it enters chiefly into building operations. A little business has been done in small lots of line pipe, and several large oil and gas interests have indicated to pipe mills that they are willing to go ahead with the laying of some large pipe lines, if they are permitted to buy at certain prices, these prices being only about 10 to 20 per cent below current quotations, so that here at any rate is a case of "the investor" naming his terms, and in substance actually making a bid. Generally speaking the investment buyer is not in the market and has not made up his mind as to the precise conditions he would require in order to bring him in.

The steel demand from the automobile trade is excellent, practically up to the highest level of the past. The automobile shops are not yet up to full production, but are rapidly being swung into line, and the makers are confident that before the end of the year they will be producing automobiles at a greater rate than ever before. They seem to be certain of their market and they are not particularly contentious as to prices to be paid for steel.

Prices to Decline

There is scarcely any doubt that finished steel prices will experience a very substantial decline by April 1. The reasoning is quite simple. Broadly speaking, there are two general classes of buying, that for current requirements and that for investment, or for construction work. The end of the war found it that the investment buyer was not ready to act and would hardly be ready until settled conditions throughout the world should become assured and prices of material and cost of labor should come down. There was no particular occasion, therefore, to consider the investment buyer in the matter of steel prices. He would not act even with a wholesale reduction. The current buyer might, however, be expected to buy in moderate fashion because he could not wait, and in keeping with this idea slight price reductions from the Government limits were made last December, averaging about $4 a ton on all products. It was thought at the time there might be another reduction of perhaps equal amount on April 1, in keeping with the quarterly consideration of prices practised by the War Industries Board during the period of control.

Developments of the past few weeks, however, have shown that even the transient or current buyer will not take hold to any extent at these prices. He has remarkable powers of staying out of the market, and he is greatly helped in this conduct by the fact that the mills can roll and ship material almost instantly on a new order. The need for maintaining stocks, on the part of the jobber and manufacturing consumer, is almost eliminated. In the late months of the war these buyers were complaining of inadequate stocks, in many cases, but the stocks were appraised according to the needs of the time, when mill deliveries were very uncertain.

Thus even the transient or everyday buyer has been failing the steel industry, and it is necessary to bring him in. Hopes have been entertained that there would be a spring buying movement of at least moderate proportions, but it appears that even that must be stimulated by price concessions. It is practically certain, therefore, that in the near future rather extensive reductions in steel prices will occur. While the steel trade is not permitted to meet and agree what it shall do, it has a spirit of following leadership, recognizing that it is necessary to have precise prices to which to adhere or utter market confusion would result. While the Steel Corporation frequently takes the lead, the prospect is that the prospective decline will be led by one of the independents, which will announce reduced prices, the other producers thereupon adopting these prices, whatever they may be. There are no definite predictions as to the size of the prospective declines. The lowest guess is that merchant steel bars will be put at 2c., from their present level of 2.70c., the Government limit having been 2.90c. That would make the reduction $14 per net ton, but it would leave bars at $12 a ton above the average of quotations in the ten-year pre-war period 1904 to 1913 inclusive. Billets in that event would probably strike around $35, with sheet bars perhaps $2 higher, and the merchant furnaces might find $25 a convenient price on which to make their fresh stand, basic being now $30 furnace, and foundry $31.

The Chemical Market

Coal-Tar Products:—While there has been no unusual volume of business noted for coal-tar products, little has developed in the way of price changes, in addition to the general list that has already been revised. Most all producers are anticipating a return to normal conditions in the trade, but, according to most reports, there is not much likelihood of any great resumption of business before the latter part of next month. Among the crude products, phenol maintains the unsettled position that has been in evidence during the recent period, while benzol is subject to a sufficient call to take the slack off the market. Some of the items are being offered in rather liberal quantities and most trading seems to be through first hands, who, for the most part, are not disposed to make any concessions to stimulate business, despite the fact that, in some instances, material is being offered through second hands somewhat below the manufacturers' prices.

Phenol:—Cheap offerings of this product seem to constitute the only activity and sales are noted as low as 8¼c., drums included. In the aggregate, a large volume of business is evident, many manufacturers having discontinued the production, as quantities of the product are offered at prices considerably below the cost of manufacture.

Benzol:—Occasional lots of this commodity reach the resale market at prices ranging from 2c. to 3c. below the manufacturers' prices. However, the market is seemingly well maintained so far as prices are concerned and is generally regarded as steady.

Toluol:—Supplies of this material are none too freely offered by second hands, and when lots of the product are offered at prices below that of the producers, there is some interest generally noted on the part of buyers. Manufacturers are firmly maintaining their prices and report a fair volume of business passing.

Naphthaline:—The consumers of this product seem to be confining their attention along conservative buying, while in the resale market a fair volume of business is passing and this is generally transacted at price conces-

sions. First hands, however, have made no price changes for the various grades of this product.

Cresylic Acid:—Foreign competition has seemingly not affected the situation up to the present and prices for this product are subject to no material change. The current call is of no pronounced volume, although sufficient trading is passing to take the slack off the market.

Paraphenylenediamine:—This material is one of the coal-tar products that has maintained a steady position in the market, and while buying seems to be confined to small lots, a satisfactory business is generally noted. The various producers continue to quote on the former basis.

Dimethylaniline:—The sales for this material are of a minor character, and the recent decline in prices has seemingly had no effect in stimulating business. Buying is conducted along conservative lines, with stocks more than sufficient for the current call.

Dinitrophenol:—A satisfactory business is reported to be passing for this product, although in most directions there seems to be an accumulation of stocks, but prices remain unchanged at the recent decline.

Diphenylamine:—There has been some little trading in this comomidity at the recent decline in prices, but for the most part individual sales are of a minor character.

Beta Naphthol:—Local trading assumes a quiet attitude and there is an absence of anything like a normal demand; however, some factors have received inquiries for the product for export purposes and it is expected that consumption in this direction may bring about a more favorable condition. Quotations generally offered are continued on the former levels for the various grades.

Monochlorbenzol:—While there is the regular consuming trade in evidence, individual sales are in small lots and stocks are fully in accordance with the current call. Second hands are unable to offer material at concessions and manufacturers are firmly maintaining prices.

Paranitraniline:—The business passing in this commodity is of no unusual volume and the extent of the recent reduction in prices does not seem to be sufficient to be attractive to buyers. Stocks of the product in the various directions seem to be accumulating, which appears to be of some concern to producers.

HEAVY CHEMICALS:—The tone of the heavy chemical market continues to reflect a feeling of uncertainty with the majority of the consuming buyers, while on the other hand trading in many of the items under this heading has been somewhat more active, and now that the holidays are over, which undoubtedly has had its effect, most operators are looking forward to a more active market. Export trading, up to the present, has been in no pronounced volume, although the general outlook is quite favorable. While there has been no general decline in prices, trading among second hands was subject to keen competition, which resulted in concessions in some instances, but in the aggregate the volume of business was not of such proportions to effect any radical changes. Soda ash and caustic soda, the products of considerable interest, maintain a rather weak position in the market and both buyers and sellers are confining their attention along quiet lines.

Soda Ash:—While there has been an absence of important price fluctuations during the interval, trading was not sufficiently active to affect the situation one way or the other. Sales of bag ash from the warehouse were consumated at $1.40 per hundred lb., with barrel ash selling at $1.75 ex-store. Light ash in bags was generally offered at from $1.75 to $1.85, while movement in double bags was particularly quiet, and for this material at Middle Western shipping points prices range from $2.15 to $2.25. Dense ash in single bags was quoted at $3.25 to $3.30 ex-store in New York, while in Philadelphia, $3.60 was asked. Double bags at the same shipping point were held at $3.10, with 3c. the general quotation at Painsville.

Caustic Soda:—Quiet trading seems to have been the feature during the past two weeks, and at periods weak holders played havoc with the market and sales for ex-warehouse material were noted at $2.75. However, for the most part, prices were fairly well maintained despite the quiet conditions. It was rather difficult to do better than $2.85 per hundred lb. at the close for resale material, while others were holding at $2.95 and $3.05, but manufacturers displayed no disposition to make any effort to meet this situation.

Bleaching Powder:—The market for this commodity continues to be quiet, with local trading confined to small lots, and while purchasing for export purposes has been of no pronounced volume, a fairly active movement in this direction is noted. There were offerings at the close, by second hands, of large domestic drums at 1½c. per lb. works, while manufacturers were quoting 2c. Material in small export drums for immediate shipment from works was offered at 2¾c. f.a.s. while the large drums were available at 2½c. f.a.s.

Copper Sulphate:—Despite the fact that manufacturers have lowered their prices for this commodity to $7.90 per hundred lb. there were offerings through second hands at $7.80 for the large crystals 99 per cent. Further reductions are not generally anticipated and business seems to be steady, but individual sales are for no important quantity and would indicate buying is conducted along conservative lines.

Cyanide of Soda:—The production of this chemical is confined to a few quarters and prices are firmly maintained, although business is of a routine nature, with the demand by no means pressing. The 96-98 per cent material is held at 30c. to 31c., while the chloride mixture of 73-76 per cent is quoted at 25c. to 27c. and the chloride carbonate mixture is offered at 20c. to 21c.

Sulphate of Alumina:—While supplies of this product are none too freely offered in the market, the consuming demand in proportion is not strong and no difficulty is experienced in meeting the situation. Prices are firmly maintained in most directions, with the iron free being held at from 3¼c. to 3¾c. per lb., while the commercial grade is quoted at 2⅜c. to 2¾c. ex-store.

Bicarbonate of Soda:—The commodity is easier and there have been some fractional declines in prices. For instance, there were resale offerings of barrel material at $2.65 per hundred lb., but manufacturers are not inclined to shade their recent quotations of $2.75.

Silicate of Soda:—A fair volume of business is noted to be passing for this material, but factors of the product report stocks in sufficient quantity to take care of additional business. The 40-degree variety seems to be somewhat easy in supply and was offered at from 2¼c. to 2⅜c. per lb. ex-warehouse, while the 60-degree product seems to be more scarce and is quoted at 4¾c. to 5c. ex-store.

Sodium Sulphide:—Local trading continues along quiet lines, while some business is passing for export purposes and prices are steady. The 60 per cent fused variety is held at 4¾c. to 5c. ex-store, while the 30-32 per cent crystals are quoted at 2⅝c. to 3c. per lb.

Bichromate of Soda:—No material improvement can be traced in this market; sales during the past week were noted as low as 12¼c. This, however, is not generally regarded a market figure with quotations at the close ranging from 12½c. to 13c.

Bichromate of Potash:—The demand for this product has been of sufficient volume to keep the spot situation well sold up and the market is in such a condition at the moment that it is rather difficult to locate spot material. The various operators are quoting 37½c. to 38½c. for material to be delivered in about ten days.

Hyposulphite of Soda:—The pea crystal product, which is the most preferable, is seemingly none too free in supply, although the spot situation, at most times, is fully in proportion to the current call. Prices are firm at from 3½c. to 3⅝c. per lb. ex-store.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET FEB. 21, 1919

Acetic anhydride	lb.	.90	—	1.00
Acetone	lb.	.15½	—	.16
Acid, acetic, 28 per cent	cwt.	3.25	—	3.50
Acetic, 56 per cent	cwt.	6.50	—	6.75
Acetic, glacial, 99½ per cent, carboys	cwt.	14.00	—	14.50
Boric, crystals	lb.	.13½	—	.15
Citric, crystals	lb.	1.25	—	1.27
Hydrochloric, (22°)	cwt.	2.50	—	3.00
Hydrofluoric, 30 per cent, in barrels	lb.	.08	—	.08½
Lactic, 44 per cent	lb.	.14	—	.15
Lactic, 22 per cent	lb.	.06	—	.07
Molybdic, C. P	lb.	6.90	—	7.40
Nitric, 36 deg	lb.	.07	—	....
Nitric, 42 deg	lb.	.08½	—	.10
Oxalic, crystals	lb.	.36	—	.38
Phosphoric, 47-50 per cent paste	lb.	.07½	—	.10
Phosphoric, ref. 50 per cent	lb.	.35	—	.40
Picric	lb.	.75	—	.85
Pyrogallic, reaublimed	lb.	2.90	—	3.20
Sulphuric, 60 deg works	ton	14.00	—	16.00
Sulphuric, 66 deg works, tank cars	ton	23.00	—	24.00
Sulphuric, oleum (Fuming), tank cars	ton	25.00	—	26.00
Tannic, U. S. P., bulk	lb.	1.40	—	1.50
Tartaric, crystals	lb.	.84½	—	.85
Tungstic, per lb. of W	lb.	1.70	—	1.75
Alcohol, sugar cane, 188 proof	gal.	4.85	—	....
Alcohol, wood, 95 per cent	gal.	1.22	—	1.24
Alcohol, denatured, 180 proof	gal.	.50	—	.52
Alum, ammonia lump	lb.	.04	—	.05
Alum, chrome ammonium	lb.	.17½	—	.18
Alum, chrome potassium	lb.	.20	—	.22
Alum, chrome sodium	lb.	.12½	—	.13
Alum, potash lump	lb.	.09½	—	.10
Aluminium sulphate, technical	lb.	.02½	—	.02½
Aluminium sulphate, iron free	lb.	.03½	—	.03¾
Ammonia aqua, 26 deg., carboys	lb.	.07	—	.08¼
Ammonia, anhydrous	lb.	.30	—	.35
Ammonium carbonate	lb.	.13	—	.14
Ammonium nitrate	lb.	.16	—	.17
Ammonium, sulphate domestic	lb.	.05¼	—	.05½
Amyl acetate	gal.	3.75	—	4.25
Arsenic, white	lb.	.09½	—	.10
Arsenic, red	lb.	.65	—	.70
Barium carbonate, 99 per cent	ton	80.00	—	90.00
Barium carbonate, 97-98 per cent	ton	65.00	—	67.00
Barium chloride	ton	65.00	—	75.00
Barium sulphate (Blanc Fixe, Dry)	lb.	.03½	—	.04
Barium nitrate	lb.	.10	—	.11
Barium peroxide, basis 70 per cent	lb.	.30	—	.32
Bleaching powder, 35 per cent chlorine	lb.	.01¾	—	.02½
Borax, crystals, sacks	lb.	.08¼	—	.08¾
Brimstone, crude	ton	65.00	—	70.00
Bromine, technical	lb.	.65	—	....
Calcium, acetate, crude	lb.	.04	—	.05
Calcium, carbide	lb.	.08	—	.10
Calcium chloride, 7-75 per cent, fused, lump	ton	22.00	—	24.00
Calcium peroxide	lb.	1.50	—	1.70
Calcium phosphate	lb.	.22	—	.23
Calcium sulpbate, 98-99 per cent	lb.	.09	—	.09½
Carbon bisulphide	lb.	.07	—	.08
Carbon tetrachloride, drums	lb.	.15	—	.16
Carbonyl chloride (phosgene)	lb.	.75	—	1.00
Caustic potash, 88-92 per cent	lb.	.55	—	.65
Caustic soda, 76 per cent	100 lb.	2.85	—	2.95
Chlorine, liquid	lb.	.10	—	.15
Cobalt oxide	lb.	1.60	—	1.65
Copperas	lb.	.01½	—	.02½
Copper carbonate	lb.	.30	—	.31
Copper cyanide	lb.	.75	—	.78
Copper sulphate, 99 per cent, large crystals	lb.	.07¾	—	.08
Cream of tartar, crystals	lb.	.58	—	.60
Epsom salt, bags, U.S.P	100 lb.	2.75	—	....
Formaldehyde, 40 per cent	lb.	.22½	—	.23
Glauber's salt	lb.	.02	—	.02½
Glycerine, bulk, C.P	lb.	.20	—	.21
Iodine, reaublimed	lb.	4.25	—	4.30
Iron oxide	lb.	.06	—	.08
Lead acetate, white crystal	lb.	.14	—	.15
Lead arsenate (Paste)	lb.	.15	—	.18
Lead nitrate, C. P	lb.	.85	—	.86
Litbarge, American	lb.	.11	—	.12
Lithium, carbonate	lb.	1.50	—	2.05
Magnesium carbonate, technical	lb.	.16	—	.17
Nickel salt, single	lb.	.14	—	.15
Nickel salt, double	lb.	.12	—	.13
Phosgene (see Carbonyl chloride)	lb.	.75	—	1.00
Phosphorus, red	lb.	.75	—	.80
Phosphorus, yellow	lb.	.50	—	.60
Potassium bichromate	lb.	.38	—	.40
Potassium bromide granular	lb.	1.25	—	1.26
Potassium carbonate calcined, 85-90 per cent	lb.	.38	—	.40
Potaseium chlorate, crystals	lb.	.40	—	.41
Potassium cyanide, 98-99 per cent	lb.	.60	—	.70
Potassium iodide	lb.	3.75	—	3.80
Potassium muriate, 80-85 p. c. basis of 80 p. c.	ton	270.00	—	285.00
Potassium nitrate	lb.	.27	—	.31
Potassium permanganate, U. S. P	lb.	1.00	—	1.05
Potassium prussiate, red	lb.	1.60	—	1.75
Potassium prussiate, yellow	lb.	.58	—	.60
Potassium sulphate, 90-95 p. c. basis 90 p. c.	ton	Nominal		
Rochelle salts	lb.	.46½	—	.48
Salammoniac, gray gran	lb.	.16	—	.18
Salammoniac, white gran	lb.	.14	—	.16
Sal soda	100 lb.	1.75	—	2.00
Salt cake	ton	18.00	—	20.00
Silver cyanide, based on market price of silver	oz.	....		
Silver nitrate	oz.	.63½	—	.64
Soda ash, 58 per cent, light, flat (bags)	100 lb.	1.45	—	1.50
Soda ash, 58 per cent, dense, flat	100 lb.	3.25	—	3.35
Sodium acetate	lb.	.12	—	.13
Sodium bicarbonate, domestic	lb.	.02¼	—	.02½
Sodium bicarbonate, English	lb.	....		
Sodium bichromate	lb.	.14½	—	.15½
Sodium bisulphite, powd	lb.	.12	—	.14
Sodium chlorate	lb.	.18	—	.19
Sodium cyanide	lb.	.30	—	.35
Sodium fluoride, commercial	lb.	.16	—	.17
Sodium hyposulphite	100 lb.	3.25	—	3.75
Sodium molybdate, per lb. of Mo	lb.	2.50	—	....
Sodium nitrate, 95 per cent	100 lb.	4.42	—	4.55
Sodium nitrite	lb.	.14	—	.16
Sodium peroxide	lb.	.35	—	.45
Sodium phosphate	lb.	.04	—	.04½
Sodium prussiate, yellow	lb.	.26	—	.28
Sodium silicate, liquid (60 deg.)	lb.	.04¾	—	.05
Sodium sulphide, 30 per cent, crystals	lb.	.02½	—	.02¾
Sodium sulphide, 60 per cent, fused	lb.	.04¾	—	.05
Sodium sulphite	lb.	.05¾	—	.06
Strontium nitrate	lb.	.25	—	.30
Sulphur chloride, drums	lb.	.07½	—	.09
Sulphur dioxide, liquid, in cylinders	lb.	.15	—	.40
Sulphur, flowers, sublimed	100 lb.	4.35	—	4.50
Sulphur, roll	100 lb.	3.70	—	3.85
Sulphur, crude	ton	35.00	—	....
Tin bichloride, 50 deg	lb.	.28	—	.29
Tin oxide	lb.	.70	—	.80
Zinc carbonate	lb.	.18	—	.20
Zinc chloride	lb.	.14	—	.14½
Zinc cyanide	lb.	Nominal		
Zinc dust, 350 mesh	lb.	.13½	—	.14
Zinc oxide, American process, works	lb.	.10	—	.12
Zinc sulphate	lb.	.04½	—	.06½

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.22	—	.27
Benzol, 90 per cent	gal.	.25	—	....
Toluol, in tank cars	gal.	.25	—	....
Toluol, in drums	gal.	.30	—	.35
Xylol, pure, water white	gal.	.45	—	.55
Solvent naphtha, water white	gal.	.20	—	.25
Solvent naphtha, crude, heavy	gal.	.15	—	.17
Creosote oil, 25 per cent	gal.	.45	—	.55
Dip oil, 20 per cent	gal.	.35	—	.40
Pitch, various grades	ton	8.00	—	20.00
Carbolic acid, crude, 95-97 per cent	lb.	Nominal		
Carbolic acid, crude, 50 per cent	lb.	Nominal		
Carbolic acid, crude, 25 per cent	lb.	Nominal		
Cresol, U. S. P	lb.	.18	—	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00	—	1.10
Alpha naphthol, refined	lb.	1.50	—	1.60
Alpha naphthylamine	lb.	.48	—	.50
Aniline oil, drums extra	lb.	.25	—	.27
Aniline salts	lb.	.36	—	.40
Anthracene, 80 per cent	lb.	.50	—	.55
Benzaldehyde (f.f.c.)	lb.	4.25	—	4.50
Benzidine, base	lb.	1.40	—	1.45
Benzidine, sulphate	lb.	1.15	—	1.25
Benzoic acid, U. S. P	lb.	1.60	—	1.65
Benzoate of soda, U. S. P	lb.	1.50	—	1.60
Benzyl chloride	lb.	.50	—	....
Beta naphthol benzoate	lb.	5.50	—	6.00
Beta naphthol, sublimed	lb.	.75	—	.85
Beta naphthylamine, sublimed	lb.	2.60	—	2.65
Dichlorbenzol	lb.	.15	—	.20
Diethylaniline	lb.	3.25	—	4.00
Dinitrobenzol	lb.	.36	—	.38
Dinitrochlorbenzol	lb.	.30	—	.35
Dinitronaphthaline	lb.	.55	—	.60
Dinitrotoluol	lb.	.40	—	.50
Dinitrophenol	lb.	.39	—	.45
Dimethylaniline	lb.	.57	—	.65
Diphenylamine	lb.	.75	—	.85
H-acid	lb.	2.35	—	2.75
Metaphenylenediamine	lb.	1.55	—	1.75
Monochlorbenzol	lb.	.16	—	.19
Naphthalene, flake	lb.	.08	—	.09
Naphthalene, balls	lb.	.11½	—	.12½
Naphtionic acid, crude	lb.	1.20	—	1.30
Naphthylamin-di-sulphonic acid	lb.	1.00	—	1.10
Nitro naphthaline	lb.	.45	—	.50
Nitro toluol	lb.	.55	—	.60
Ortho-amidophenol	lb.	6.00	—	7.00
Ortho-dichlor-benzol	lb.	.15	—	.20
Ortho-toluidine	lb.	.50	—	.90
Ortho-nitro-toluol	lb.	.75	—	.85
Para-amidophenol, base	lb.	3.25	—	3.65
Para-amidophenol, H. C. L	lb.	3.75	—	4.25
Para-dichlor-benzol	lb.	.15	—	.20
Paranitraniline	lb.	1.35	—	1.45
Para-nitro-toluol	lb.	1.50	—	1.60
Paraphenylenediamine	lb.	3.25	—	3.50
Para toluidine	lb.	1.85	—	1.95
Phthalic acid anhydride	lb.	3.25	—	3.50
Phenol, U. S. P	lb.	Nominal		
Resorcin, technical	lb.	4.50	—	5.00
Resorcin, pure	lb.	7.00	—	8.00
Salicylic acid, U. S. P	lb.	.55	—	....
Salol	lb.	1.10	—	1.15
Sulphanilic acid, crude	lb.	.25	—	.31
Toluidine	lb.	2.45	—	....
Toluidine-mixture	lb.	.80	—	1.00

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	4.00	—	....
Corning, Ohio	bbl.	2.85	—	....
Somerset, Ky	bbl.	2.60	—	....
Wooster, Ohio	bbl.	2.58	—	....
Indiana	bbl.	2.28	—	....
Illinois	bbl.	2.25	—	....
Oklahoma and Kansas	bbl.	2.25	—	....
Caddo, La., light	bbl.	2.10	—	2.25
Corsicana, Tex., light	bbl.	2.25	—	....
California	bbl.	1.24	—	1.57
Gulf Coast	bbl.	1.25	—	....
Mexican	bbl.	1.90	—	....
Fuel Oil				
New York	gal.	.15	—	....
Philadelphia	gal.	.10½	—	....
Baltimore	gal.	.07½	—	.15
Pittsburgh	gal.	.07½	—	.10½
Texas	bbl.	1.85	—	2.35
Los Angeles	bbl.	1.65	—	....

Gasoline (Wholesale)

New York, motor	gal.	.24½	—	.....
Gas machine	gal.	.41½	—	.....
72-76 degrees	gal.	.33½	—	.39½
70-72 degrees	gal.	.32	—	.37½
67-70 degrees	gal.	.30½	—	.36½
Pittsburgh, motor	gal.	.25½	—	.....
Chicago, motor	gal.	.21	—	.....
Oklahoma, motor	gal.	.23½	—	.....
San Francisco, motor	gal.	.20½	—	.....

Paraffine Waxes

Crude, 103 to 105 deg. m.pt	lb.	.08½	—	.09
Crude, 118 to 120 deg. m.pt	lb.	.09½	—	.10
Crude, 124 to 126 deg. m.pt	lb.	.10	—	.....
Refined, 120 deg. m.pt	lb.	.13½	—	.....
Refined, 128 deg. m.pt	lb.	.14	—	.....
Refined, 135 deg. m.pt	lb.	.16	—	.16½
Ozokerite, brown	lb.	.75	—	.80
Ozokerite, green	lb.	.85	—	.90

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.23	—	.24
Cylinder, light	gal.	.42	—	.44
Cylinder, dark	gal.	.39	—	.43
Paraffine, high viscosity	gal.	.40	—	.41
Paraffine, 0.903 sp. gr.	gal.	.33	—	.34
Paraffine, 0.885 sp. gr.	gal.	.26	—	.28

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f. o. b. Florida	gal.	.44	—	.....
Pine oil, steam-distilled, sp. gr. 0.925-0.940	gal.	.58	—	.60
Pine oil, destructively distilled	gal.	.58	—	.60
Pine-tar oil, sp. gr. 1.02-1.035	gal.	.35	—	.....
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal	.42	—	.....
Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f.o.b. works	gal.	.37	—	.....
Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.28	—	.....
Pine-tar oil, ref., thin, sp. gr. 1.060-1.080	gal.	.32	—	.....
Turpentine, crude, sp. gr. 0.870-0.900	gal.	.45	—	.....
Hardwood oil, f.o.b. Michigan, sp.gr. 0.960-0.990	gal.	.23	—	.....
Hardwood oil, f.o.b. Michigan, sp.gr. 1.06-1.08	gal.	.23	—	.....
Wood creosote, ref., f.o.b. Florida	gal.	.31	—	.....

Naval Stores

Rosin A-E barrel	280 lb.	13.10	—	13.20
Rosin F-I	280 lb.	13.20	—	13.50
Rosin K-N	280 lb.	15.50	—	16.65
Rosin WG-W	280 lb.	16.75	—	17.10
Spirits of turpentine	gal.	.70	—	.....
Wood turpentine, steam distilled	gal.	.64	—	.65
Wood turpentine, destructively distilled	gal.	.63	—	.65½
Pitch	bbl. 200 lb.	8.00	—	.....
Tar, kiln dried	280 lb.	13.00	—	13.50
Retort tar	280 lb.	14.00	—	14.50
Rosin oil, first run	gal.	.74	—	.....
Second run	gal.	.76	—	.....
Third run	gal.	.72	—	.....
Fourth run	gal.	.92	—	.....

Vegetable Oils

Castor oil	lb.	.21	—	.29
China wood oil	lb.	.23	—	.24
Cocoanut oil	lb.	.14	—	.19
Corn oil	lb.	.13	—	.17
Cottonseed oil, crude	lb.	.17½	—	.22
Linseed oil, raw, cars	gal.	1.45	—	1.48
Palm	lb.	.18	—	.21½
Peanut oil, crude	lb.	.14½	—	.21
Soya bean oil, Manchuria	lb.	.12½	—	.15

Glues

Extra white	lb.	.31	—	.35
Cabinet	lb.	.25	—	.26
Brown foot stock	lb.	.15	—	.19
Fish glue, 50-gal. barrels	gal.	1.00	—	1.50

Miscellaneous Materials

Barytes, floated, white, domestic	ton	33.00	—	36.00
Beeswax, white, pure	lb.	.63	—	.65
Beeswax, unbleached	lb.	.43	—	.48
Blanc fixe	lb.	.05½	—	.....
Casein	lb.	.17½	—	.30
Chalk, light, precipitated, English	lb.	.04½	—	.06
China clay, imported, lump	ton	20.00	—	40.00
China clay, domestic, lump	ton	15.00	—	22.50
Feldspar	ton	8.00	—	12.00
Fluorspar, gravel, f. o. b. mines	ton	28.00	—	40.00
Fluorspar, washed, powdered	ton	90.00	—	.....
Fuller's earth, powdered	100 lb.	1.50	—	2.00
Graphite Alabama	lb.	.08	—	.12
Ceylon	lb.	.09	—	.22
Madagascar	lb.	.10	—	.15
Mexican	ton	35.00	—	75.00
Japan wax	lb.	.18	—	.19
Orange shellac	lb.	.72	—	.80
Pumice stone	ton	.04	—	.08
Soapstone	lb.	15.00	—	25.00
Stearic acid	ton	.20½	—	.22½
Talc, American, white	ton	20.00	—	40.00

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	100.00	—	120.00
Chrome cement	net ton	75.00	—	.....
Clay brick, first quality fireclay	per 1000	40.00	—	50.00
Clay brick, second quality	per 1000	35.00	—	40.00
Magnesite, raw	ton	30.00	—	35.00
Magnesite, calcined, powdered	net ton	50.00	—	65.00
Magnesite, dead burned	net ton	38.00	—	40.00
Magnesia brick, 9x4½x2½	net ton	110.00	—	125.00
Silica brick	per 1000	45.00	—	55.00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent, carloads, f. o. b. Niagara Falls, N. Y	ton	200.00	—	250.00
Ferrocerium	lb.	15.00	—	30.00
Ferrochromium, per lb. of Cr	lb.	.30	—	.40
Ferromanganese, domestic, 70 per cent basis	ton	150.00	—	200.00
Spiegeleisen (16-18%)	ton	57.00	—	58.00
Ferromolybdenum, per lb. of Mo	lb.	3.50	—	4.50
Ferrosilicon, 50 per cent, contract	ton	120.00	—	125.00
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	Nominal		
Ferrouranium, f.o.b. works, per lb. of U	lb.	7.50	—	.....
Ferrovanadium, f.o.b. works	lb.	....	—	.....

Ores and Semi-finished Products

Chrome ore, 45 per cent minimum, f.o.b. Cal. per unit	ton	1.50	—	1.55
Coke	ton	6.00	—	7.00
Petroleum Coke	ton	16.00	—	.....
Manganese ore, 48 per cent and over, per unit	ton	1.20	—	.....
Manganese ore, chemical	lb.	80.00	—	100.00
Molybdenite, per lb. of MoS_2	ton	.80	—	.85
Tungsten, Scheelite, per unit of WO_3	ton	17.00	—	24.00
Tungsten, Wolframite, per unit of WO_3	lb.	15.00	—	21.00
Uranium oxide, 96%	lb.	3.25	—	3.60
Vanadium pentoxide, 99%	unit	10.50	—	.....
Pyrites, foreign	unit	.17	—	.....
Pyrites, domestic		.28	—	.30½

Plant Supplies

BUILDING MATERIALS

Common clay bricks	M	14.00	—	15.00
Faced Brick	M	37.00	—	46.00
Hollow tile, 4x12x12	M	60.00	—	.....
Hollow tile, 12x12x12	M	170.00	—	.....
Lime	ton	16.50	—	.....
Portland cement	bbl.	2.59	—	.....
Single glass (82-lb.), 10x26-16x24		21.00	—	27.00
Double glass (164 lb.), 10x26-16x29	M	31.00	—	39.00
Yellow pine lumber	M	39.00	—	45.00
Cypress	ton	70.00	—	.....
Tarred felt (14-lb. sq.)	ton	61.00	—	.....
Roofing pitch	sq.	27.00	—	.....
Asphalt coated roofing (35-55-lb.sq.)	sq.	1.60	—	2.45
Slate surfaced asphalt shingles	ton	5.25	—	5.50
Corrugated galvanized iron	100 lb.	109.00	—	127.00
Putty	100 lb.	6.25	—	.....
Red oxide (Ppte. Copperas)	100 lb.	15.00	—	20.00
Native red oxide	100 lb.	3.25	—	8.00
Red metallic paint	100 lb.	1.20	—	1.50
White lead in oil	100 lb.	15.00	—	16.00
White lead (dry.)	100 lb.	11.00	—	13.00
Red lead in oil	100 lb.	12.28	—	14.50
Red lead (dry)	100 lb.	14.50	—	.....
Zinc oxide (dry)	100 lb.	13.00	—	14.50
Zinc oxide—leaded	100 lb.	9.00	—	10.00
Yellow ochre	100 lb.	1.50	—	10.00
Ultra marine blue	100 lb.	14.00	—	50.00
Prussian blue	100 lb.	135.00	—	150.00
Chrome green	100 lb.	40.00	—	70.00
Paris green	100 lb.	43.00	—	49.00
Mineral black	100 lb.	1.75	—	2.25
Powdered bone black	100 lb.	5.50	—	12.00
Lampblack	100 lb.	15.00	—	45.00
Gas carbon	100 lb.	16.00	—	25.00
Mexican petroleum pitch	100 lb.	1.00	—	2.00
Gilsonite	100 lb.	2.00	—	2.50
Coal tar pitch	100 lb.	.60	—	1.25

STRUCTURAL IRON

Blue annealed sheet iron	ton	77.00	—	82.00
Black sheet iron	ton	90.00	—	96.00
Galvanized iron	ton	101.00	—	131.00
Tern plate, 8-lb. coating	ton	145.00	—	148.00
Tern plate, 15-lb. coating	ton	175.00	—	.....
Tern plate, 25-lb. coating	ton	200.00	—	.....
Tern plate, 40-lb. coating	ton	230.00	—	.....
Tin plate, prime	ton	147.00	—	155.00
Tank plates	ton	60.00	—	65.00
Beams, channels, angles, T's, Z's	ton	56.00	—	60.00
Rivets	ton	88.00	—	92.00
Steel pipe, ¾ to 3-inch	ton	51.00	—	.....
Bar iron and steel	ton	60.00	—	70.00
Chain (1 inch proof coil)	ton	150.00	—	.....
Nails, bolts, nuts, washers	ton	70.00	—	80.00
Tool steel, special alloys	ton	300.00	—	500.00
Bessemer pig iron	ton	32.00	—	35.20
Bessemer steel	ton	43.50	—	47.50
No. 2 foundry	ton	37.90	—	.....
Steel billets (4 x 4)	ton	47.50	—	.....

POWER HOUSE SUPPLIES

Steam packing, rubber duck	lb.	.99	—	1.10
Asbestos, high pressure	lb.	1.76	—	.....
Asbestos, wired	lb.	1.30	—	.....
Asbestos, graphited braid	lb.	1.21	—	.....
Asbestos, wick	lb.	.75	—	.....
Rubber, sheet	lb.	.66	—	.....
Cup grease	lb.	.07	—	.....
Transmission grease	lb.	.07	—	.....
Axle grease	lb.	.04½	—	.....
Gear grease	lb.	.04½	—	.....
Cotton waste	lb.	.08½	—	.11
Hose, underwriters, 2½ in	ft.	.75	—	.....
Hose, air, ¾ in	ft.	.50	—	.60

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Arizona

AGUILA—The Bullard Mining Co., Wickenburg, will build a new leaching plant at its properties here.

BOUSE—The Arizona Desert Mining & Milling Co., Bisbee, will install two ball-mill units supplementing 20-ton mill now on ground and operated. J. H. King, superintendent.

Colorado

EUREKA—The Empire State Mines & Reduction Co., will build a 50-ton unit of the 100-ton concentrating mill near here, and is in the market for lumber, crushers, rolls, classifiers, concentrating tables, pulleys, belting, meters, roofing, pipe, etc. Estimated cost, $25,000. W. Akers, superintendent.

Connecticut

HARTFORD—The city will build a slow sand filtration plant, consisting of eight half-acre filter beds and a 40 x 40 ft. laboratory building. Address Chief Engineer, Hartford Water Works, Room 702, Pilgard Building.

Georgia

SAVANNAH—The Southern Fertilizer & Chemical Co., American Bank & Trade Building, will rebuild its plant, recently destroyed by fire, entailing a loss of $225,000.

Idaho

BONNERS FERRY—The Cyanide Gold Mining Co., recently incorporated with a capital of $3,000,000, has taken over the property of the Deer Creek Gold Mining Co., near here and will develop same. Plans include the construction of a large cyanide plant.

CALDWELL—The School District is having plans prepared by Wayland & Fennell, architects, Idaho Bldg., Boise, for the construction of a two-story, concrete high school building. Plans include the installation of a chemical laboratory and scientific rooms. Total estimated cost, $75,000.

NAMPA—The city will build a 700,000-gal. disposal plant in connection with the new sewerage system. L. R. Cook, City Hall, engineer.

PINE CREEK—The Nabob Consolidated Mining Co., Kellogg, will build a new concentrating plant at the works here. Estimated cost, $50,000. H. C. Barnett, Kellogg, manager.

Illinois

EAST ST. LOUIS—The Obear-Nestor Glass Co., Broadway and Belt Line R.R., has awarded the contract for the construction of a two-story, 82 x 192 ft. glass factory, to Keeley Bros., Belt and State Sts. Estimated cost, $65,000.

ROCK PARK—The Rock Falls Box Board Co. will build a three-story, 120 x 135-ft. factory and is in the market for equipment for same. Total estimated cost, $130,000. J. L. Carey, 208 North Laramie Ave., Chicago, engineer.

Kentucky

OWENSBORO—The Glenmore Distilleries Co. will build a distillery for the manufacture of alcohol.

Maryland

BALTIMORE—The Liberty Yeast Corporation, incorporated by J. Bannister Hall, 609 Calvert Building, and associates, with $3,000,000 capital, has acquired the Monumental Distillery at 11th and O'Donnell Sts. and will remodel and equip same for the manufacture of yeast and its by-products.

CANTON (Baltimore P. O.)—J. M. Jones, 1621 Park Ave., Baltimore, and associates, have acquired a site on 5th Ave., and will build a tin manufacturing plant. Estimated cost, $500,000.

HYATTSVILLE—The Washington Suburban Sanitary District is having plans prepared by R. B. Morse, engineer, 324 North Charles St., Baltimore, for impounding the waters of Patuxent, Little Patuxent and Middle Patuxent Rivers to develop water supply. Project includes the construction of a rapid sand filtration plant, etc. Estimated cost, $2,500,000.

Michigan

DETROIT—The Board of Education will develop the laboratory in the Central High School building, Cass and Warren Aves., cost $47,160; equipment for same, $2500; filtering and sterilizing equipment for swimming pool in Cass Technical High School, $10,700.

DETROIT—The Water Board has recommended the City Council to build a complete filtration plant. Estimated cost, $5,326,000. G. H. Fenkell, chief engineer.

HOLLAND—The DePree Chemical Co., 133 West Washington St., Chicago, Ill., will build a chemical plant here.

PONTIAC—The City Clerk will receive bids until June 1 for the construction of a sewage disposal plant, including Imhoff tanks and trickling filters. Estimated cost, $300,000. H. H. Barnett, City Hall, engineer. Noted Feb. 1.

RIVER ROUGE—The Semet-Solvey Co., Milton Ave., Syracuse, N. Y., will build a 50 x 150 ft. acid washing machine house here.

Missouri

CARROLLTON—The Water, Light & Transit Co. will install a modern water filtering system and make other improvements to its property. S. J. Jones, Carroll Exchange Bank Bldg., president.

JOPLIN—The Texas Mining & Milling Co. will install a complete 150-ton mill and is in the market for a hoisting engine, blower engine and derrick boiler. Estimated cost, $25,000. E. D. James, manager.

Minnesota

WASHINGTON—The Directors of the Southwestern Minnesota Sanitarium have awarded the contract for installing a filter plant here, to W. Danforth, Germania Life Building, St. Paul. Estimated cost, $13,660.

Montana

NEIHART—The Cascade Silver Mines & Mills will install a concentrater and trams and is in the market for machinery necessary for the repair and upkeep of same. Estimated cost, $300,000.

Nebraska

OMAHA—The State Legislature plans to appropriate $40,000 for electrical apparatus, laboratory equipment, etc. J. Latenser & Sons, 632 Bee Building, architect.

New Jersey

CAMDEN—J. Evansen & Son, Delaware Ave. and Pennsylvania R.R., will rebuild its soap factory, recently destroyed by fire, and is in the market for machinery for same, including drying and molding machinery, belts, conveyors, heating bags, dry kilns etc. Estimated cost, $150,000.

ELIZABETH—The United States Leather Co., 356 Magnolia St., has awarded the contract for the construction of a two-story, 115 x 220 ft. factory, to the Turner Construction Co., 244 Madison Ave., New York City. Estimated cost, $200,000.

KEARNY—Swift & Co., 32 10th Ave., New York City, N. Y., will rebuild its fertilizer works, boiler plant, etc., here, recently destroyed by fire, entailing a loss of $150,000.

NEWARK—Elmer & Amend, 13-17 Margaretta St., has awarded the contract for the construction of an addition to its chemical plant, to Anthony Imhoff, Inc., 248 West 18th St., New York City. Estimated cost, $3500.

NEWARK—Kelly & McLaughlin, 93 Colder St., will build an addition to its plant for the manufacture of leather. Estimated cost, $8000. A. Peter, 828 Broad St., architect.

New York

NEW YORK—The Commissioner of Water Supply, Gas & Electricity, Municipal Bldg., has awarded the contract for furnishing and delivering liquid chlorine, to the Hooker Electrochemical Co., 40 Wall St., $7955; chloride of lime, to Arnold Heffman, Providence, R. I., $1094, respectively. Noted Feb. 15.

POUGHKEEPSIE—The State Hospital Commission, Capitol, Albany, received bids Feb. 11 for building intake crib in the Hudson River, thence to filters, installing new filters, also changing water mains and reservoir at the Hudson River State Hospital, here, from C. R. Simpson, 90 West St., New York City, $57,887; H. E. Fox Construction Co., 81 East 125th St., New York City, $58,000; New York Sewage Disposal Co., 37 East 28th St., New York City, $62,997. Noted Feb. 1.

Ohio

IRONVILLE—The Paragon Refining Co., 2935 Front St., Toledo, will build a refining plant here. Estimated cost, $100,000.

Oklahoma

MIAMI—The Alexander Lead & Zinc Co. will build a mill and develop property here. Estimated cost, $75,000. G. M. Ramsey, superintendent.

Oregon

ASTORIA—The Astoria Pulp & Paper Co. will build a paper mill on 11th St. and Tayler Rd. Estimated cost, $250,000.

Pennsylvania

BLAIRSVILLE—S. S. Richard, Altoona, will build a hospital and group of institutional buildings near here, consisting of sewage dispesal plant, reservoir, administration building, etc. F. McCrooks, Jones Law Building, Pittsburgh, architect.

PHILADELPHIA—N. Drassner, 1909 South 6th St., will build a two-story, 48 x 116 ft. chemical factory at 612-616 Moore St. Estimated cost, $20,000. H. H. Kline, 536 Mifflin St., engineer.

South Dakota

ABERDEEN—Dr. R. L. Mudry will receive bids until March 18 for the construction of a chemical building here. J. W. Henry, architect.

Texas

NORTH FORT WORTH—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will receive bids until March 10 for the construction of an argon production plant here, to consist of an office and laboratory building, lime storage shed, compression building, separation building, pressure reducer house, nitregen cylinder house, carbon dioxide removal system and lime mixing shed. Estimated cost, $607,250

FORT WORTH—The Evans Thwing Refining Co. has awarded the contract for the construction of an oil refinery, to the Reeves Bros., Alliance. Noted Dec. 30.

McKINNEY—The Texas Cotton Mills Co. will build an indigo-dye plant. Estimated cost, $60,000.

SAN ANGELO—The city will install a filtration plant. Estimated cost, $30,000. R. H. Henderson, mayor.

YOAKUM—The Texas Hide & Leather Co., recently organized, will build a factory for the manufacture of coarse grades of leather. A. Hofheinz, manager.

Virginia

ORANGE—The West Virginia Timber Co., 510 Charleston National Bank Building, Charleston, W. Va., will build an acid and byproducts plant and saw mill here. Estimated cost, $500,000. G. E. Breece, president.

ROANOKE—The United States Potash & Brick Corp., recently incorporated with $1,000,000 capital, will build a plant to have a daily capacity of 25 tons of caustic potash. O. T. Dennhardt, Box 956, manager.

Washington

TURNER—The Loon Lake Copper Mining Co., 408 Columbia Bldg., Spokane, will build a concentrating mill to have a daily capacity of 100 tons. J. McCormick, president.

West Virginia

CLARKSBURG — The Clarksburg Water Board will build a one-story, 20 x 25 ft. filtration plant and install filter equipment and piping.

Alberta

EDMONTON—The City Council will build an addition to the filtration plant. Estimated cost, $30,000. C. E. K. Fox, clk.

British Columbia

KIMBERLY—The Consolidated Mining & Smelting Co. will build extensive additions and improvements to the concentration plant to treat the increased tonnage of the Sullivan mine here.

PORT MOODY—The Moody Rolling Mills, Ltd., Pacific Building, Vancouver, will build a steel rolling mill here.

VANCOUVER — The Bowena Copper Mines, Ltd., 419 Rogers Bldg., will build a concentrating mill. C. M. Oliver, secretary.

VICTORIA — The Tudhope Electric Metals, Ltd., will build a smelting plant. Estimated cost, $8700.

Ontario

CONISTON—The Mond Nickel Co. will establish three new furnaces, thereby doubling the capacity of its plant. C. V. Corliss, manager.

HAMILTON—The Dominion Foundries & Steel Co., Ltd., is receiving bids for the construction of a new plate mill having a capacity of 12,000 tons per month. Noted Feb. 1.

NORWAY—The city will build a sewage disposal plant. Address J. Brown.

OTTAWA—The Board of Control will soon award the contract for furnishing 30,000 lb. of liquid chlorine. A. F. MacCallum, engineer.

OTTAWA—The Canadian Government will establish a Central Resources Institute at an initial cost of $600,000 for buildings and laboratory equipment. The general idea is that the institute should combine the functions of the Bureau of Standards at Washington, D. C., also the duties of the Mellon Institute at Pittsburgh, Penn.

PORT ARTHUR J. J. Carrick, 13 Cumberland St., N., will build a pulp and paper plant. Estimated cost, $7,500,000. H. S. Ferguson, 200 5th Ave., New York City, engineer, preparing plans.

Quebec

MONTREAL—The Commissioners of the schools of Coteau and St. Pierre are in the market for equipment for their new chemical laboratory, manual training and art departments. D. I. Spence, 246 Beaver Hall, architect.

QUEBEC—Price Bros. Co., Ltd., 56 St. Peter St., will build a new pulp mill. Estimated cost, $1,000,000.

QUEBEC—The Valcartier Lumber & Pulp Co., Ltd., will receive bids in March for the construction of a pulp mill. Estimated cost, $350,000.

Coming Meetings and Events

THE AMERICAN CHEMICAL SOCIETY will hold a meeting in Buffalo, April 7 to 11.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its annual meeting in New York City from April 3 to 5.

THE CANADIAN MINING INSTITUTE will hold its twenty-first annual meeting on March 5 to 7, 1919.

THE NATIONAL FOREIGN TRADE COUNCIL will hold its sixth National Foreign Trade Council at the Congress Hotel, Chicago, Ill., on Thursday, Friday and Saturday, April 24, 25 and 26, 1919.

THE SOCIETY OF INDUSTRIAL ENGINEERS plans a national conference at New York March 18-21 at the Hotel McAlpin, at which there will be a discussion of labor by both employers and labor leaders. Internal plant organization and also the elimination of fatigue will be other leading topics.

Industrial Notes

THE ALL-RUSSIAN CENTRAL UNION OF COOPERATIVE SOCIETIES invites American manufacturers and producers to send price lists and catalogs in duplicate to the headquarters of the Union, Liebes Building, 167 Post St., San Francisco, Calif. It is stated that the All-Russian Central Union represents the bulk of Russia's buying power.

THE WELLMAN-SEAVER-MORGAN CO., Cleveland, Ohio, held its annual meeting of stockholders on Feb. 18 and re-elected the retiring board of directors as follows: Edwin S. Church, F. E. Borton, W. H. Cowell, F. B. Richards, S. T. Wellman, E. H. Whitlock of Cleveland, S. H. Pitkin, Francis Seiberting and F. A. Seiberling of Akron, O. The directors have elected the following officers: Edwin S. Church, president and general manager; S. H. Pitkin, vice-president; Geo. W. Burrell, second vice-president; and W. H. Cowell, secretary and treasurer. Mr. G. W. Burrell, who was elected second vice-president, has been in the continuous employ of the company for twenty-one years. He will have entire charge of the company's works both at Cleveland and Akron.

For the purpose of aiding American manufacturers in expanding export trade to the twelve nations of Central Europe and Asia Minor which recently declared their independence and formed an alliance known as the Mid-European Union, and to expedite the delivery to these countries of such materials as is needed by them, a bureau of information and education has been created with offices in the Union headquarters, McLachlen Building, 10th and G Streets, N. W., Washington, D. C. The countries which have pledged themselves to the Union of Independence through official representatives in this country are: Czecho-Slovaks, Poles, Jugoslavs, Ukrainians, Uhros-Rusins, Lithuanians, Rumanians and Italian Irredentists. Unredeemed Greeks, Albanians, Zionists and Armenians. The following are the representatives in this country: T. G. Masaryk, (for the Czecho-Slovaks), T. M. Helinski, (for the Poles), Dr. Hinko Hinkovic (for the Jugoslavs), Nicholas Ceglinsky (for the Ukrainians), Gregory Ignatius Zsatkovich (for the Uhro-Rusins), Thomas Norus Narusevicius (for the Lithuanians), Capt. Vasile Stoica (for the Rumanians), Charles J. Tomazolli (for the Italian Irredentists), Christos Vassilakaki (for the Unredeemed Greeks), Christo A. Dako (for the Albanians), Itzamar Ben-Avi of Jerusalem (for the Zionists), G. Pasdermadjian (for the Armenians). The bureau announces that the Central European countries are in immediate need of materials and commodities of every description and it is the intention to gather all available information valuable to the manufacturers of this country with as to the character of goods desired and as to specifications. In other words, the bureau will act in an advisory capacity to both the purchaser and seller. Mr. J. Nichols is assisting in directing the affairs of the bureau.

Manufacturers' Catalogs

THE MILWAUKEE RELIANCE BOILER WORKS, Milwaukee, Wis., calls attention to Bull. No. 101, on Sharp-Bassett gas producers. This booklet describes and illustrates combined steam and gas generators, improved gas producer, gives a curve showing the full consumption of a modern producer gas engine at various loads, comparative costs of power of various types of engines and producer gas for power and fuel.

THE SHAWINIGAN ELECTRIC-METALS CO., Ltd., Montreal, Canada, has issued an attractive booklet, No. 2, dated Dec. 2, 1918, entitled "Shawinigan Magnesium," which contains 36 pages on foundry practice in using magnesium, physical properties, chemical properties, chemical uses, alloys, table of comparative costs, commercial forms, packing and quality.

THE WESTINGHOUSE ELECTRIC & MFG. CO. and associated companies have issued the annual catalog of electrical supplies containing a list of all apparatus manufactured by the company or obtainable through its district offices and agent-jobbers. The catalog, comprising 1264 pages, contains a complete cross index and supply number index.

THE SCIENTIFIC MATERIALS CO., Pittsburgh, Pa., has just issued a "Blue Book" of scientific laboratory equipment. The distinguishing feature of this catalog is that not a single item listed is "Made in Germany." This is noteworthy when it is considered that the catalog comprises over 650 pages and contains a complete list of apparatus, equipment and chemicals.

THE DEISTER CONCENTRATOR CO., Fort Wayne, Ind.: Bull. No. 3 illustrates and describes in 24 pages Deister-Overstrom Diagonal Deck Concentrating Tables.

THE GREEN FUEL ECONOMIZER CO., Beacon, N. Y., has just received an attractive booklet from the press, Bulletin 151, on "Green's Economizers." This 64-page booklet deals with the first economizer, heat of fuel present in flue gases, economizer practice, secondary advantages, special uses, photographs of installations, steam tables and dimensions.

THE WESTINGHOUSE ELECTRIC & MANUFACTURING CO., East Pittsburgh, Pa.: Catalog 33, entitled Westinghouse Alternating-Current Motors, describes and illustrates in 80 pages classification and selection of a-c motors, squirrel-cage induction motors, headstock motor equipments for woodworking lathes, wound-rotor induction motors, elevator motors, type AR, single-phase, constant speed motors and also synchronous motors.

HAMILTON & HANSELL, INC., New York, has issued a booklet on the Rennerfelt electric arc furnace which illustrates and describes this furnace.

Stocks and Bonds

Closing Bid and Asked Quotations Feb. 26, on N. Y. Stock Exchange

CHEMICAL COMPANIES

	Bid	Ask		Bid	Ask
Am. Ag. Ch...	102	102½	Mat. Al. Wk..	34	44
do. pf.....	98½	99½	Ten. C. & C..	13	13½
Barrett Co...	118	119½	Un. Dyewood	50	61
do. pf.....	110½	113	do. pf.....	90	...
Gen. Chem...	165	173	Va.-Car. Ch..	54½	55
do. pf.....	102½	103½	do. pf.....	112	113
Int. Ag. Ch..	14	15			
do. pf.....	58	58½			

Bonds

Am. Ag. Ch., 1st cv. 5s, '28	99½	100½
Am. Ag. Ch., cv. db. 5s, '24	102	103
Int. Ag. Ch., 1 mtg. & col. tr. 5s, '32	79½	80
Va.-Car. Ch., 1 mtg. 5s, '23	95½	96
Va.-Car. Ch., cv. db. 6s, '24	100½	102

PETROLEUM COMPANIES

	Bid	Ask		Bid	Ask
Asso. Oil Co..	71½	74	P-A Pet & Tr	79½	79¾
Cal. Pet.....	26½	27	do. pf.....	135	140
do. pf.....	72	72½	Pierce Oil....	17½	17½
Col. G. & E..	45½	45½	Royal Dutch.	94½	95½
Mex. Pet....	177	177½	Sinclair O. & R.	36	36½
do. pf.....	105	109	Texas Co.....	193	193½
Ohio Cit. Gas.	37½	37½	Tex. Pac. Ld.		
do. pf.....	...	...	Tr.....	240	290
Ohio Fuel S..	44	45	Tidewater Oil.	221	225
Okla. P. & W..	8½	8¾			

Bonds

Columbia Gas & Electric, 1 5s, '27	81½	82½
Col. G. & El., std. 1 5s, '27	81½	82½
Pan-Am. Pet. & Tr. 1 6s, '19-'27	130	...
Pierce Oil, cv. db. 6s, '24	92	92½
Pierce Oil, cv. 5% Notes, '20	101	101½
Sin. O. & R. 1 ln. 7s, '20, with stk. war.	99½	99¾
Sin. O. & R. 1 ln. 7s, '20 without stk. war.	96	96½
Texas Co., db. 6s, '31	101½	102
Unioo Oil of Cal. 1 5s, '31	93	94
United Fuel Gas 1 mtg. 6s, ser. A, '36	95½	97

IRON AND STEEL SECURITIES

	Bid	Ask		Bid	Ask
Am. St. F....	81½	82	Pitts. Stl, pf.	90	98
Beth. Steel..	63½	64½	Rep. Iron &		
do. class B.	64½	64¾	Steel.....	77½	77¾
do. pf., 8%.	104½	104½	do. pf.....	101½	102½
do. pf., 7%.	92	100	Sloss Sheff. I.		
Central Fdry.	18	21	& S.....	50½	50¾
do. pf.....	34	39	do. pf.....	86	...
Col. F. & I...	38	38½	Superior Steel	36	36½
do. pf.....	99	...	do. 1 pf...	95	99
Cruc. Steel...	60	60½	Trana. & W.		
do. pf.....	90½	91½	Steel.....	38½	40
Great No. Ore	39½	39½	Un. Alloy St..	41½	42
Gulf Sta. Steel	52	53	U.S.C.I.P.&F.	19	19½
do. 1 pf....	94	99	do. pf.....	53	55
Lack. Steel...	66½	67	U. S. Steel...	95½	95¾
Mid. St.& Ord	42½	42½	do. pf.....	114	114½
Nova Scotia			Va. Coal, I&C	54	60
Steel.....	49	...			

Bonds

Beth. Steel, 1 ext. gtd. S.F. 5s, '26	95½	96½
Beth. Steel, 1 ln. ref. 5s, Ser. A, '42	88½	89
Beth. Steel, P. M. & I. S. F. 5s, '36	81	82
Buff. & Susq. Iron, 1 S. F. 5s, '32	91	96
Buff. & Susq. Iron, deb. 5s, '27	...	...
Cent. Found. 1 mtg. S. F. 6s, '21	80	82
Col. F. & I., gn. S. F. 5s, '43	86½	90
Ill. Steel, db. 4½, '40	84½	85½
Ind. Steel, 1 mtg. gtd. 5s, '52	97	98½
Lack. Steel, 1 5s, '23	96½	97½
Lack. Stl., 1 con. mtg. cv. 5s, Ser. A, '50.	86½	87
Mid. St. & Ord., clt. cv. S. F. 5s, '36	86½	86½
Nat. Tube, 1 mtg. gtd. 5s, '52	96	98
Rep. I. & S., S. F. mtg. 5s, '40	95	95½
Tenn. C. & I. R. R., gn. 5s, '51	91½	95½
U. S. Steel, S. F. 5s, '63	100½	100½
Va. C., I. & C., 1 5s, '49	87	89½

Published SEMI-MONTHLY *on the* FIRST *and* FIFTEENTH *of each month*

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

McGRAW-HILL COMPANY, INC.
Tenth Avenue at 36th Street
NEW YORK

JAMES H. McGRAW, President
ARTHUR J. BALDWIN, Vice President E. J. MEHREN, Vice President
J. MALCOLM MUIR, Vice President EDWARD CALDWELL, Treasurer
JAMES H. McGRAW, JR., Secretary

TELEPHONE, 2840 Greeley CABLE ADDRESS, Machinist, New York

WASHINGTON, Colorado Bldg. SALT LAKE CITY, Newhouse Bldg.
CHICAGO, Old Colony Bldg. PHILADELPHIA, Real Estate Trust Bldg.
SAN FRANCISCO, Rialto Bldg. CLEVELAND, Leader-News Bldg.
LONDON, 6 Bouverie St., E. C. 4.

H. C. PARMELEE, Editor
ELLWOOD HENDRICK, Consulting Editor
ERNEST E. THUM, Western Editor
WALLACE SAVAGE, Assistant Editor

Yearly Subscription price for United States, Mexico and United States dependencies, $3; *all other countries,* $4. *Single Copy,* 25c.
When change of address is ordered, the NEW and the OLD addresses must be given. Notice must be received at least 10 days before change takes place. No back copies for more than three months.

Copyright, McGraw-Hill Co., Inc., 1919. Entered as second-class matter July 13, 1918, at the Post Office at New York, N. Y., under the Act of Congress of March 3, 1879.

Circulation of this issue 12,400 copies

CONTENTS *for March* 15, 1919

Volume XX, *Number* 6

EDITORIAL
Speaking of Propaganda....257
The Blight of Blatherskite Rule....257
Metallurgy and Civilization....258
German Chemical Patents Take On New Aspects....258
Sulphur Patents Are Decreed Invalid....259
Deflating Prices Mobilizing Industry....259
READERS' VIEWS AND COMMENTS
Colloidal Condition of Silver Chloride. By *R. F. Wood*....260
The Analysis of Red Lead. By *W. F. Edwards*....260
Economics of the Zinc Industry....260
Furnace Settings for Caustic Pots. By *Frank H. Nickle*..261
Novel Method for Treating Sulphur Ore. By *Kirby Thomas*....261
Twenty-first Annual Meeting of the Canadian Mining Institute....262
Report of Alien Property Custodian on the Chemical Industry..264
Fate of the Water-Power Bill....265
American Welding Society to Be Organized....265
German Requisitions in Poland....265
Magnetic Concentration of Pyrrhotite Ores. By *J. P. Bonardi*....267
The Engineer as a Citizen....270
National Association for the Protection of American Rights in Mexico....270
Work of the United States Employment Service....270
Observations on Flaky and Woody Steel. By *Federico Giolitti*....271
American Electrochemical Society, New York Meeting....273
Fusibility of Coal Ash. By *W. A. Selvig, W. C. Ratliff* and *A. C. Fieldner*....274
Change in Method of Distribution of Bureau of Standards Standard Samples....276
Decomposition of Metals—I. By *Col. A. I. Krynitzky*....277
New Process for the Manufacture of Sulphonic Acids....282
Temperature Uniformity in an Electric Furnace. By *John B. Ferguson*....283
Exports of Glycerine in 1918....288
Imports of Platinum Into the United States....288
Improved Treatment of Burns....288
British Import Restrictions....288
Production of Hydrogen and Water Glass by the Silicol Process....289
Fuel Economy in the Boiler House—III. By *John E. C. Kershaw*....291
Chemical Trade Statistics....295
Imports and Exports....295
Recent Chemical and Metallurgical Patents....296
Personal....298
Obituary....298
Current Market Reports—Non-Ferrous Metal Market, Iron and Steel Market, Chemical Market and Chemical Price List....298
Industrial News, Coming Meetings and Events, Stocks and Bonds....303

Speaking of Propaganda

ACCORDING to a time-honored custom, the dancers usually defray the expense of the orchestra. So Germany, having indulged in a wild orgy and frightful revelry for four years, is about to be presented with the bill; and signs are not lacking that she is looking furtively about for a side exit through which she may escape the collector. The whining press dispatches emanating from her political leaders urging justice and leniency on the part of the Allies, and even threatening dire consequences if the Peace Conference lays on too heavy an indemnity, are but palpable attempts to secure sympathy from thoughtless minds.

German propaganda is still in our midst—deceptive, insidious, baneful. It rears its head on the front page of the daily press, in whispered talk on the street and in published interviews with prominent personages. It is the most effective weapon left in the hands of an unchastened and unrepentant nation, and it can yet work untold harm unless intelligent people steel their hearts against it. In many respects it is unfortunate that Germany was not whipped into decisive military defeat, because that outcome might have chastened her pride and brought home a lively sense of the enormity of her crimes. Perhaps this desirable end may yet be accomplished when her people realize that the bill must be paid and that it is huge beyond the dreams of the indemnities which her own rulers had planned to exact from the Allies. No qualms of conscience or false spirit of magnanimity should deter those who are charged with fixing the terms of peace from exacting the last full measure of just reparation from Germany. Her land is unscarred by shot and shell; her factories and machinery are intact; her people have homes and will get food enough for subsistence; she has natural resources such as potash that can be administered in the interest of the Allies; her people are sufficiently accustomed to heavy taxation to warrant continuance of that means of securing national funds. In short, Germany is able to pay, and no amount of propaganda should swerve the Allies from the only course that will satisfy the great mass of their peoples.

The Blight of Blatherskite Rule

EVERY issue of *Science* contains memoranda of the shift, by leading men, from the faculties of colleges and universities over to industry. Of the change from industrial work to the high estate of professorship there are very few notes. In the Employment Bureau

of the Chemists' Club there are constantly increasing applications for positions as chemists, but only a few applicants are even willing to teach, far less desirous of so doing. The exodus from teaching seems to be more particularly from the so-called freshwater institutions: the State colleges and the universities of interior States.

Now, teaching is the greatest of the arts, and while its emoluments are seldom high, many such posts offer opportunities for research, and also for consultation. Despite the incursions of dancing masters and sleight-of-hand performers, there still inheres a great dignity to the title of professor. What is the trouble, then? We answer, frankly, politics. Trustees are appointed who are without scholarship or educational ideals. They do not even know enough to keep their hands off what they do not understand. Sometimes a strong administrator in the person of the president can prevent them from meddling, but often again the trustees are too ignorant to forbear. They make life impossible for a conscientious educator.

The ideals of the majority of our State colleges and universities are splendid. The student bodies are no less than inspiring. They are eager to learn, and they lack the extra-academic "activities" which beset many of the Eastern institutions to the inhibition of serious study. The whole organization would be most promising, if it were not for a succession of dunderhead trustees appointed by the vagrant fancy of a series of transient Governors.

What these institutions lack is democracy at the top. Democracy implies working together, which is something the political trustees cannot understand. They strut about in their comedy authority, and insult professors and instructors; they make foolish demands, and they connive to replace useful and gifted teachers with their own relatives and friends. They interfere with discipline in the interest of grocers and haberdashers. A goodly number of them are infernal nuisances, for it is within the power of a single trustee to destroy the morale of a great institution.

We are disposed to favor a civil service commission to pass on all nominees for the trusteeship of colleges and universities that receive Federal aid, with the power to remove those who prove incompetent. The need for good instructors is pressing, very pressing, and many of the best are leaving their posts because of unendurable conditions, brought about by blatherskite rule!

Metallurgy and Civilization

SAVANTS have pictured primitive man a beast of the jungle mouthing almost meaningless gibberings. Fortunately he discovered fire, and with this knowledge migrated into more temperate zones, where later with his new-found friends, a bow and arrow, he became hunter instead of hunted. Perhaps in this dim, uncertain eon the savage picked up yellow gold and white tin in the stream beds by which he penetrated the pathless forests, or found red copper in the ashes of a fire fortunately builded under boulders of ore. And in some way one found that white and red metal would melt together to form a different thing we now call bronze. When the savage learned that this new metal could be made into superior tools and weapons he was a savage no longer.

Long millenniums of barbarism then passed, during which ancient man progressed mightily by virtue of his inherited wisdom. The making and the use of pottery in cooking reacted powerfully on his development; he changed from hunter to herdsman or farmer by the domestication of animals and the invention of irrigation. Yet the bronze age passed after ages of groping metallurgy, when the ancient smith produced steel in his primitive forge and discovered how to harden it after being cunningly wrought. Metallurgy had again opened the gates of civilization!

All this happened long before the invention of writing, and is known to us only by the remaining fragmentary handicraft of the ancient artisan. Recorded ideas now enabled man's culture to advance with increasing speed to but yesterday, when gunpowder and the printing press leveled society, physically and mentally. Perhaps the last great step toward the latest civilization has just been taken by Watt and his steam engine. But meager indeed would be our comforts had not the modern metallurgist responded to the need of huge quantities of cheap steel for bridges and ships, rails and boilers, of strong metals for axles and engines, of special alloys for electrical and domestic uses.

The word metallurgy images to many minds a small, dark, smoky, smelly iron foundry, or to others a high board fence surrounding furnaces glaring with white heat, and powerful machinery superhuman in power and dexterity. But in its entirety modern metallurgy influences our civilization down even to the commonest tools of life, and the initiated wonders to what state of savagery we would drop should it become a lost art.

German Chemical Patents Take On New Aspects

THE Chemical Foundation, Inc., has recently been formed to take over the 4500 German chemical patents at present owned by enemy aliens. The charter of the corporation is so framed that under the patents non-exclusive licenses only can be granted on equal terms to all proper applicants and must be granted to the United States free of cost. By Executive order obtained under the provisions of the Act of Nov. 4, A. Mitchell Palmer, Alien Property Custodian, has sold to this company for the sum of $250,000 all the German chemical patents which have been taken out in the United States.

It is well known that the German patents were not taken out to obtain exclusive manufacturing rights in this country, but to maintain exclusive sales. The sales departments of the various German companies feared Swiss, French and English competition and prevailed upon their manufacturing department to allow it to work out patent descriptions of processes which would protect their features but not disclose their actual methods of manufacture. As a matter of fact, the methods usually described were chosen for their excellently small yields. A mere sample of the product was all that was needed to fill the patent requirements and satisfy the sales department by furnishing it with a weapon to strike down competition.

Such an end to the mass of faked, camouflaged, false patents is as glorious as the victory in Europe. However,

the final success of the venture will require addition to the board of directors of men as eminent in the field of industrial science as the present members are in legal, executive and financial circles. The Chemical Foundation, Inc., will not be a commercial success unless it can supply manufacturing yield methods as well as patents. It cannot fail in doing some good in that it will prevent foreign competition on the commodities covered by its patents. Not having been formed for financial profit, vast sums of money will be collected and expended. Co-operation will be obtained to an extent not hitherto conceived, but men with a scientific insight should be in the pilot house as well as below the deck.

Sulphur Patents Are Decreed Invalid

THE United States Circuit Court, sitting at Philadelphia, has dismissed the infringement suit of the Union Sulphur Co. vs. the Freeport-Texas Co. with the verdict that the patents lacked inventive substance.

Too many patents of doubtful validity are being issued which may or may not be of sufficient financial value to merit such a costly legal battle as has just been closed with the Frasch sulphur patents. While we are cleaning up the German patent system, can we not extend the good work and establish patent limits?

Deflating Prices Mobilizing Industry

THROUGH the proposals of Secretary of Commerce Redfield war-time prices are to be deflated and industry is to be mobilized for normal peace-time activity. The principle of *laissez faire* is not to be allowed to obtain in the commodity markets. It is pointed out on behalf of the Industrial Board of the Department of Commerce, formed under Secretary Redfield's plan, with George N. Peek as chairman, that the law of supply and demand cannot be expected to cure what it did not create.

The condition of war-time control of prices, set at a high level in order to stimulate production, is not the only instance of the law of supply and demand not operating. It is a facile assumption that when prices are under control by pools or agreements among sellers, things interdicted by the Sherman law, the law of supply and demand is altogether suppressed, while when such agreements are suppressed the law of supply and demand operates. No more egregious blunder could be made. Time after time the iron and steel industry has given the plainest testimony that such is not the case. Repeatedly after a period of heavy buying and advancing prices it has, without agreement, held to existing prices neither because of agreement nor because of demand balancing supply, but merely and solely because the individual producers all recognized that to cut prices would be to precipitate a great decline, demand being too light to establish a price level only slightly lower than the existing one, and being certain, moreover, to be diminished rather than increased by price reductions. The mills had unfilled obligations with customers, and a break in the market would kill more of that tonnage than it would produce new tonnage. There was less to gain than to lose.

By and by the time arrived when the steel mills observed that there was more to gain than to lose by giving prices a free rein. Bottom was then reached and the market eventually recovered, a new "buying movement" being inaugurated. Thus the endless cycle has been followed. If steel were not used for construction or "investment" purposes, if jobbers and manufacturing consumers pursued a rule of maintaining the same stocks at all times, and if mill deliveries against orders were made with the same degree of promptness at all times, prices of steel might fluctuate quite closely in accordance with the supply available and the actual consumptive demand. As it has been, the expressed demand exceeded at one time the actual consumptive demand and at other times fell short of it. Construction jobs were undertaken partly in a speculative spirit, being proceeded with not solely because the facility was needed at the particular time, neither sooner nor later, but because the buyer did not wish to overstay a rising market. Let us be thankful, therefore, that at last circumstances so clear and compelling have arisen as to force the admission that the law of supply and demand does not always set prices when the conspiracies in restraint of trade, interdicted by the Sherman law, do not exist.

There is no doubt that Secretary Redfield's Industrial Board will be able to accomplish some very good results. Judge Gary in his address to representatives of the iron and steel industry on March 6 referred to Mr. Redfield as "a very wise and thoughtful man," and Mr. Peek, chairman of the Industrial Board, who in turn addressed the meeting, impressed the manufacturers as being a man of true business instincts.

The board has two sources of power. In the first place, it can furnish assurance to a given industry that the co-operation of all industries will be sought for the purpose of securing the reduction in prices of building materials essential to the resumption of construction work. The brickmakers do not care to reduce prices if the steel producers do not, nor the steel producers if the cement makers do not, since for the full stimulation of construction work all items of cost should be reduced. Each industry, no doubt, would be willing to make its contribution if others would co-operate.

In the second place, the Industrial Board has the lever of Government or Government-controlled purchases. The Navy Department has considerable buying to do and some other Government departments have not a little, while there is a large volume of railroad buying that could be compassed if prices were made reasonably attractive.

To avoid possible disappointment, however, it should be recognized that the contemplated operation has its limitations. It cannot create an ideal condition on which years of industrial activity can be built. It does not know precisely how eager the investor will be to exchange "safe" investments, such as many bonds, for works of construction. It does not know precisely how hard workmen are going to be willing to work in future. It can develop a "recommended" price for merchant steel bars, perhaps even for screw stock and shafting, but must stop before it gets to farm implements, machine tools and automobiles. In particular, it seems to be the program to carry the activities, in establishing or re-establishing the law of supply and demand, only to the point of time when through decrease in the cost of living and other influences it will be fitting and proper that wages should decline. Wage declines, with fresh deflation of prices, will hardly be under Government auspices.

Readers' Views and Comments

Colloidal Condition of Silver Chloride

To the Editor of Chemical & Metallurgical Engineering

SIR:—Reading the editorial notes on Colloids in your issue of Oct. 15 made me recall an instance of what I suppose was a colloidal condition of silver chloride. This was encountered in laboratory control of the operation of a blast furnace that treated slag from reverberatory furnaces in which Lake copper concentrates were smelted.

In making determinations of the silver content of the impure copper ("cupola blocks") yielded by the blast furnace, it was noticed that at times the silver chloride, formed by adding HCl to the nitric solution of the copper, failed to settle out completely, even after one or more days of standing. Inspection of the records of such cases showed that they occurred uniformly whenever the blast furnace charge included, together with regular slag from the smelted concentrates, any considerable proportion of the slag that was formed from the reverberatory refining of "cupola blocks" themselves. I do not know whether any especial interest attaches to the foregoing, but offer it merely as an observation. R. F. WOOD.

Sandusky, Ohio.

The Analysis of Red Lead

To the Editor of Chemical & Metallurgical Engineering

Sir:—Soon after the publication of "Notes on the Analysis of Red Lead" in CHEMICAL & METALLURGICAL ENGINEERING, Jan. 1, 1919, my attention was called to "A Rapid Method for the Analysis of Red Lead and Orange Mineral" published in the *Journal of Industrial and Engineering Chemistry*, March, 1916. This is a hydrogen peroxide-potassium permanganate method and is said to be finding more and more favor with large users of red lead on account of its simplicity and accuracy.

As to its simplicity and easy adaptability to routine methods there is no question. However, I should simplify the details given in the paper referred to. There is no need of hot water or dilution and it is quite as simple to use a regular N/10 permanganate solution with a factor 0.03428 for the Pb_3O_4 as to use a computation based on an iron value of the permanganate.

As to the accuracy of the method, I have compared it on three samples of red lead with the iodide method, having standardized the permanganate with Bureau of Standards standard sodium oxalate and with ammonium ferrous sulphate. The sodium thiosulphate used in the iodide method was standardized with this permanganate. The samples were weighed with the same one-gram weight on the same balance and the titrations were made from the same section of a single burette at room temperatures not varying more than one degree during the analyses.

Sample I. By iodide, 92.55 and 92.55 per cent; by peroxide, 91.61, 91.32, 91.90, 91.63, 91.96 per cent. Average, 91.62 per cent.

Sample II. By iodide, 90.49 and 90.49 per cent; by peroxide, 89.95, 89.71, 89.71, 90.15, 90.50 per cent. Average, 90 per cent.

Sample III. By iodide, 87.07 and 87.07 per cent; by peroxide, 87.74, 87.07, 87.41, 87.38, 86.81 per cent. Average, 87.30 per cent.

In the peroxide method the permanganate was measured in a second burette and two burette readings are necessary, while in the iodide method only one burette reading is taken and represents the iodine actually freed by the red lead and not a left over portion of a measured in amount of reagent. This probably accounts for the variations in the numbers for the peroxide method.

On the whole I should say the checks were as close as could be expected and sustain the claim for simplicity and accuracy. W. F. EDWARDS.

Detroit, Michigan.

Economics in the Zinc Industry

To the Editor of Chemical & Metallurgical Engineering

SIR:—I hope that the discussion caused by your recent publications on zinc metallurgy may lead to tangible results, and not to the usual very general and non-committal statements. Unfortunately for the writer, as is doubtless the case with numerous others, the invitation to participate in such discussion should really come from the metallurgist's superiors, and will be lacking in most instances.

It has been my experience that the capital which is backing the zinc smelters will not permit very radical changes unless the chances for success are good, and therefore I believe that the near future will show only gradual improvements. The vertical retort with continuous charging is likely to be the first effort of our industry not only to improve the retorting practice now in vogue, but also to overcome the labor shortage on the one hand and the growing inefficiency of labor on the other.

Roasting of zinc ores will, in my opinion, continue and should most certainly be accompanied by the extraction of sulphuric acid. However, the roasting process itself is in almost greater need of radical improvement than is the smelting. There is really no entirely efficient and satisfactory roaster in existence today, especially for the flotation concentrates, which will presently be the only type of ore we are asked to smelt.

Briquetting of furnace charges has been tried again and again, but in spite of its obvious advantages has not been worked out to a definite success. The large amount of air which is invariably present with briquetted charges appears to be the greatest drawback in retorting, and we may have to use a combination of briquets and the usual fine retort charge to reduce the voids.

The greatest difficulty in the retorting of zinc ores is still the condensation of the metallic fumes, and practically no progress has been made in improving the existing condensers, or in designing a new type.

The often disagreeable working conditions, the presence of excessive heat and obnoxious fumes, and the great physical effort now required, must be overcome to make the future zinc smelter a place to which labor will be attracted. We will have to get away from the methods of producing zinc by the spoonful, and must develop apparatus which will yield the best metallurgical results possible, combined with the lowest amount of labor needed, and at the same time take the responsibility for the finer points in our art out of the hands of practically trained labor, and vest it in the metallurgist, as is customary in the smelting of iron and copper.

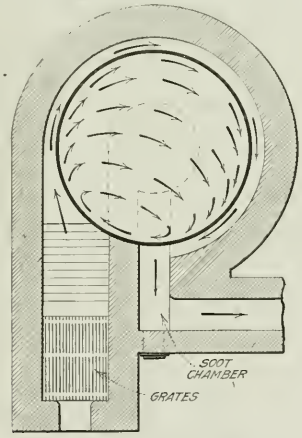
ZINC SMELTER.

Furnace Settings for Caustic Pots

To the Editor of Chemical & Metallurgical Engineering

SIR:—Referring to my article, "Furnace Settings for Caustic Pots," which appeared in your Jan. 15 issue, please note that the words "counter-current economizer" in the caption under the title should have been omitted. As stated in the text on page 67, particularly in the claim quoted from my patent, the liquor in the pot is caused to rotate by means of the tangential application of the products of combustion to the exterior of the pot, the direction of travel being concurrent with the rotation of the liquor.

Also, you will note that the arrows, indicating the direction of the liquor rotation in the right-hand pot in Fig. 3, page 65, were inadvertently pointed in the wrong direction. This probably accounts for the use of the words "counter-current" referred to above.



CIRCULATION OF LIQUOR IN NICKLE TANGENTIAL DUTCH OVEN

My theory, as to why the natural rotative circulation of the liquor is concurrent rather than counter-current with the heating gases, is illustrated in Fig. 1. The heating surface adjacent to the combustion chamber is subjected to the most intense heat, whereas the reverse is true at the end of the circumferential travel of the heating gases or adjacent to the soot chamber.

Starting with a pot of cold liquor, the two temperature extremes being in close proximity, it is evident that convection or eddy currents will be set up in the liquor, the direction of which will be clockwise as indicated. Gradually the cold particles of liquor, remote from the high temperature heating surface, come within the influence of these eddy currents until the arcuated path of active circulation is established tangentially to the orbital heating surface, and in substantially a horizontal direction with reference to arcs struck about the axis of the pot, the rotation being in the direction of decreasing application of heat, or concurrent with the travel of the heating gases.

FRANK H. NICKLE.

Saginaw, W. S., Mich.

Novel Method for Treating Sulphur Ore

To the Editor of Chemical & Metallurgical Engineering

SIR:—The war stimulus to the sulphur mining industry resulted in the serious attempt to develop and operate numerous Western sulphur deposits, mostly of solfataric origin and not adapted to the application of the celebrated Frasch underground liquation process to the problem of the recovery of the native sulphur from the gangue with which it is associated. Heretofore the method in use in this country was the liquation process, using the principle of melting or liquefying the sulphur in a closed chamber or retort by means of superheated steam and the recovery of the sulphur by simple drainage methods. This apparatus in any of the forms used was expensive to operate and the recovery of the sulphur was very low, sometimes not more than 25 per cent; besides it was costly in operation and very uncertain as to results under the varying physical conditions of the material to be treated. Several mechanical adaptations of this method have been resorted to, but in general the process is a very imperfect one from the standards of cost and efficiency.

Attempts to recover the sulphur by flotation have been made in the laboratory and by means of experimental plants, and there is promise of very good results in this line. However, the problem has engaged the attention of a number of operators, with the result that some novel metallurgical ideas have been evolved, at least to the experimental stage. One of these is based on the familiar "shot-tower" idea. The sulphur with the gangue is submitted to treatment under pressure by superheated steam, with the result that the sulphur is liquated and drains through the perforated bottom of the retort along with more or less of the fine gangue and dirt, the separation of which from the liquid sulphur is one of the problems of other liquation applications. In falling a short distance, not more than 10 ft., the sulphur forms small spheres in a similar manner to the action of the streams of molten lead in the shot tower, and at the bottom of the chamber there is accumulated a mixture of these "shots" and the fine material. The sulphur "shots" are very pure and free from dirt and fine rock. Their further separation is an easy matter of screening and separation by methods familiar in other applications. This novel metallurgical idea is being tried out in an experimental way in Chicago, and patents have been applied for.

It is interesting to consider whether the idea might have application to any other metallurgical operations and whether its possibilities in the sulphur field are of importance.

KIRBY THOMAS.

New York City.

Twenty-First Annual Meeting of the Canadian Mining Institute

Report of Business and Technical Sessions, With Special Reference to the Production of Such War Minerals as Manganese, Platinum, Chromite and Molybdenite—National Research and International Co-operation—D. H. McDougall Elected President

THE Canadian Mining Institute celebrated the attainment of its majority at the annual meeting held in Montreal, March 5-7, 1919. In his opening address President D. B. DOWLING referred to the cordial and friendly relations existing between the Canadian and American mining engineers, as evidenced by the exchange of visits at the annual meetings of the respective societies. This practice has been growing in recent years and should become an established custom. It was again referred to by MR. H. V. WINCHELL, president of the A. I. M. E., who spoke on the subject of international co-operation in mining, and who advocated intermingling of Canadian and American mining engineers as an effective measure for making imaginary boundary lines non-existent except for political purposes.

President DOWLING reviewed the assets of Canada and said that her economic aim should be to develop her natural resources and thereby improve her local markets. Canada's products should be offered to the world in manufactured form whenever possible; and he placed on mining engineers the responsibility of developing in the highest degree the mineral resources of the Dominion.

CHANGE OF NAME PROPOSED

At the annual business meeting the Institute became involved in a long discussion over DR. STANSFIELD'S resolution to change the name from Canadian Mining Institute to Canadian Institute of Mining and Metallurgy. Difference of opinion centered mainly in the function of the Institute—whether it was devoted to the general industry of mining without regard to the different phases, such as mining, metallurgy, geology and chemistry, or whether it was a professional body concerned with the technology of methods and processes. Discussion seemed to favor the former view, *i.e.*, that the Institute is devoted to the mining industry as a whole and is not primarily a technical organization. DR. STANSFIELD'S resolution was disposed of by referring it to the membership at large for letter ballot.

Certain amendments to the by-laws were proposed and referred to the membership. One related to classification of membership, introducing the grade of "professional member"; and the other was concerned with the election of officers and council. The purpose of establishing "professional members" was the convenience of council in dealing with other engineering bodies in Canada on subjects involving the professional status of mining engineers. The object of the amendment relating to officers and council was to provide machinery whereby the Institute would be in closer touch with the interests of the provinces. It calls for an increase in the number of vice-presidents from four to six; the redistricting of the Dominion into six districts which shall have direct and equal representation on council.

The question of the salaries received by technical employees in the civil service of the dominion and provincial governments was discussed at some length, and finally the Institute passed a resolution urging the Government to provide larger salaries for its officials and employees whose duties call for technical training.

MR. D. H. MCDOUGALL, president of the Nova Scotia Steel & Coal Co., was elected president of the Institute for the ensuing year.

SYMPOSIUM ON MOLYBDENUM AND CHROMIUM

Several papers were scheduled dealing with the mining, concentration and metallurgy of molybdenum and chromium ores. MR. B. C. LAMBLE described the manufacture of ferromolybdenum at Orillia, by smelting in the electric furnace a mixture of green or raw concentrates of molybdenite with lime and carbon. Eighty per cent of the molybdenum fed to the furnace was recovered. Volatilization losses were very low, but there was a dust loss of 11 per cent and a slag loss of 7 per cent. Ninety per cent of the metal in the latter, however, was recovered by table concentration.

Recent progress in the concentration of molybdenite was discussed by MR. H. H. CLAUDET. He cited Elmore's successful pioneer work in concentrating molybdenite by flotation more than thirteen years ago, and he reviewed the later work of Wood in developing the film-flotation machine and process which had been so successful in producing molybdenum concentrates during the war. Still a later development was the application of the Callow cells with the adjunct of a screen to separate the flocculent molybdenite from the granular silica pyrite. In a flow-sheet which he exhibited the ground ore was first floated in a rougher cell which yielded a finished tailing and a dirty concentrate, the latter being cleaned in a second cell. The second tailing was returned to the rougher cell because it was quite rich in molybdenite. The concentrate contained some pyrite and silica, and these were separated by passing the concentrate over a Callow traveling-belt screen. The molybdenite formed flocks which remained on the screen and were readily separated from the impurities which passed through. This latter product was returned to the rougher cell on account of its high molybdenum content, and ultimately the silica and pyrite would go out with the cell tailing, while the molybdenite would flocculate and be caught on the screen. This method effected a 95 per cent recovery in a concentrate containing 90 per cent MoS_2. The utility of screening

was shown in raising the grade of a 3 per cent MoS_2 flotation concentrate to 65 per cent, and one of 12 per cent to 76. In discussion it was brought out that soluble sulphates interfered with the process, as also did chalcopyrite. Mica was not objectionable unless present in large amounts. Oxidized ores of molybdenum did not yield well.

New occurrences of chromite in Canada were described by DR. ROBERT HARVIE in an illustrated lecture; and the concentration of chromite was the subject of a paper by MR. L. K. FLETCHER. Discussion elucidated the fact that Canadian chromite could be produced and sold at a profit for $1 per unit in 50 per cent concentrate, as against the quoted price of $1.75 per unit for the New Caledonian product. It would be essential, however, to have at least $1 per unit for the domestic product in order to provide insurance against the irregular ore-bodies.

War-Time Search for Platinum and Manganese

The lengths to which Canada went in an effort to secure adequate supplies of needed war minerals were well shown in an illustrated lecture by MR. G. C. MACKENZIE. He described his explorations on the Saskatchewan River and on the Tulameen in British Columbia, where large areas were prospected with hand augurs and with Empire and Keystone drills. Work on the Tulameen yielded results of 35c. per cu.yd. in gold and platinum, and was considered encouraging; but winter set in before drilling could be carried further, and the war ended before the winter was over. The area is still regarded as worth investigation by private concerns.

Manganese was sought on the Island of Vancouver and some deposits were found carrying from 30 to 50 per cent. The matter of making ferromanganese on the Canadian Pacific coast was investigated, and it was finally determined to be commercially impracticable on account of the cost of power. With ferromanganese selling at $100 per ton in the Eastern metallurgical centers, and Western power costing 7 mills per kw.-hr., the scheme would not be feasible. Power at 2 mills would be necessary for success. Canada used 1000 tons of ferromanganese monthly during the war, and had to import all of it from the United States or Great Britain.

International Co-operation in the Mining Industry

One day of the session was designated as American Institute Day, and was devoted to joint discussions relating to industrial relations, principles of taxation, co-operation among small concerns in the same district, etc. MR. H. C. PARMELEE outlined the changes that have been and are occurring in the relations between employer and employee, citing the most advanced customs among the leaders of industry in Europe and the United States. The subject of taxation was presented by MR. THOMAS W. GIBSON. SIR JOHN WILLISON spoke in advocacy of Government aid to the mining industry just as it is given to the agricultural or fishing industries. He approved the bounty for metal production and urged the participation of the Government in the development of the country through national industrial and scientific research. He thought that technical societies should address themselves to the education of legislators in regard to research, and hold sessions at the capital while Parliament is in session so that members might attend some of the meetings. Special programs for the information of legislators would be an effective method of education.

The Problem of National Research

DR. A. P. MACALLUM of the National Advisory Research Council addressed the Institute on the functions of the Council, which are as follows: (a) The investigation of standards of weight, measure, volume, etc.; (b) standardization of technical and scientific apparatus; (c) standardization of raw materials and products of Canada used in the arts and industries; (d) improvement of technical processes; (e) research to promote the utilization of the natural resources of Canada; and (f) the encouragement of trade research associations, to be assisted by the Government with free quarters and expert advice. He regarded the last as the most important function of the Council because through the development of Canada's potential industries she would be enabled to meet her future debts, pensions, etc. His remarks were the subject of an adjourned meeting at which the policies and proposals of the Research Council were warmly discussed and finally made the subject of a resolution in which the C. M. I. council was directed to investigate the proposals of the Advisory Council of Scientific and Industrial Research and determine the advisability of the proposed procedure.

Applying Powdered Coal in Blast Furnaces

A paper of unusual metallurgical interest was that of MR. W. L. WOTHERSPOON on the use of pulverized fuel in smelting copper-nickel ores in the blast furnaces. He reviewed the experiments started by the Tennessee Copper Co. and later by the International Nickel Co. The conditions at the two plants are essentially different, because the former has a charge consisting mainly of lump ore, while the latter uses 75 per cent of roasted ore that gives a screen analysis showing 53 per cent on 1½ in., 16 per cent on 1 in., and 31 per cent through 1 in. Tests now under way have been going on for more than two months and considerable economies in fuel consumption have been effected. The powdered coal is blown into the furnace through the tuyeres, the same grade of coal being used as for reverberatory firing. Plans are under way to apply the method to lead smelting. Mr. Wotherspoon's paper will be published in the *Transactions* of the C. M. I.

MR. E. J. CARLYLE described some special equipment that had been devised for a copper smelter in Russia. It consisted mainly in four-compartment charge cars, ore bins and smelting furnaces, designed to save time and labor as well as distribute the charge effective in the furnace. A feature of the furnace was a water-cooled cast blister-copper spout which was found necessary in order to resist the action of a very corrosive matte.

MR. W. FLEET ROBERTSON gave the results of an investigation of a hoisting cable which had failed in very light service. It was found that the exterior of the rope was sound and appeared to be in good condition, while at the same time spots in the interior were

badly corroded, thus weakening the rope. A method of electrical testing was devised, depending on measurement of the resistance of the rope every three or four feet. This was found effective in locating corroded spots. As a preventive against this corrosion it was recommended that periodically the rope be immersed in hot liquid grease, as the ordinary surface greasing was insufficient.

The meeting was marked by a number of social features, including a smoker and the annual banquet. At the former there was an exhibition of films showing Canadian forces in action in the Great War, as well as an illustrated lecture on General Allenby's campaign in Palestine, by DR. H. M. AMI. Two lectures on military tunneling and mining were given by MAJOR R. W. COULTHARD and CAPT. L. B. REYNOLDS. At the annual dinner the principal speech was made by the DUKE of DEVONSHIRE, Governor-General of Canada. He lent official support to the project for industrial research and to Government aid for the mining industry. Not the least important of his remarks related to the unity of interest of the employer and the employee, and the necessity for generous and broad-minded treatment of our industrial problems. In this connection he saw a large duty devolving upon engineers.

Report of Alien Property Custodian on the Chemical Industry

THE activities of the alien property custodian have been too extensive ever to be fully reported, but interesting reading is to be found in the voluminous report filed this week. Three of the Big Six German dye companies, Bayer, Berlin and Kalle, did not give Mr. Palmer much trouble, but the Badische, Hoechst and Cassella proved to be quite elusive. These latter concerns were nominally owned by Messrs. Kuttroff and Pickhardt; Herman A. Metz; and Matheson and Shaw; however, an actual German ownership existed in each case. The Cassella Company U. S. patent assignments were recorded, but the fact that Messrs. Matheson and Shaw immediately reassigned them to the parent German concern was a secret. As the National Aniline & Chemical Co. was dependent on these patents, the title to which was supposedly transferred to it by the recorded owners, it can be seen how interested the Germans might have continued to be in the new American Co. The Metz transfer will prove equally illuminating and we quote verbatim from Mr. Palmer's report:

THE HOECHST COMPANY

The American branch of the great Hoechst Co. had for many years been conducted by Mr. Herman A. Metz. Prior to 1912, the New York corporation was known as H. A. Metz (Inc.), and a majority of its stock was always owned by the parent house. In that year the German company took over all but 10 shares of the minority stock which had previously stood in the name of Mr. Metz, leaving him the record owner of these 10, the only shares not held by them. At the same time the name of the New York corporation was changed to Farbwerke-Hoechst, so that the value of the good will might be firmly fixed in the German name. At about this time the anti-trust proceedings above referred to were commenced against these companies also. Mr. Metz settled for $40,000 the suit commenced against his company, and proceeded to make strong representations to the German house to the effect that the stock ought to be owned by him so that it could no longer be asserted that the German house was no longer doing business in America. A prolonged negotiation ensued, the Germans being very reluctant to make any change. At last in the summer of 1913 it was arranged that the 1990 shares held by the German concern should be transferred on the books to Mr. Metz; that in return he should execute a demand promissory note without interest for the sum of $597,000; that the note should be delivered to the German company, and the stock, together with a suitable transfer properly executed, should be deposited to the sole order of the German concern in a Montreal bank, as security for the note.

HOW PROFITS WERE DIVIDED

At this time and for many years previous the American company had been operating under a contract by which the German house appointed it its sole American sales agent and agreed to furnish it with goods, in return for which the profits were to be divided according to an arbitrary scale, irrespective of stock ownership. Under this arrangement the Germans were to have one-half the profits of the color business and 75 per cent of the profits of the pharmaceutical business, which, owing to the development of salvarsan and novocaine, had become of great importance. In return, and as a check on possible overcharges by the German house, Mr. Metz was to receive a percentage of their profits on the sales to the American company. An irrevocable power of attorney was given to Mr. Metz to vote the stock owned by the German company in the New York house and an option was reserved to the German company to purchase the stock in the event of Mr. Metz's death or retirement.

PROFITS SENT TO GERMANY AS LONG AS MONEY COULD BE REMITTED

This contract was continued unaltered after the stock transaction of 1913, and under it the profits were divided as long as it was possible to remit moneys to Germany. There was also an oral understanding between the parties that the note should not be payable except out of the stock or its proceeds, and that it could not be demanded as long as Mr. Metz should remain president of the company. It will thus be seen that the whole stock dealing produced no change whatever upon the rights of the parties. After it, as before, the share in the profits of each party remained the same; power to secure and pass title to the certificates remained as before in the hands of the German company alone; the voting power remained as before in Mr. Metz's hands; in fact none of the incident of ownership was in any way affected by the transaction.

At the outset Mr. Metz filed reports stating the existence of the note and the fact that certain stock was deposited as security for the same, but it was not until the ascertainment of the entire history of the transaction that the proof could be obtained that the transfer was not and was not intended to be of any effect. At last, however, the investigation thoroughly demonstrated this, and the stock has accordingly been taken over by me.

The Roessler & Hasslacher Chemical Co. people were equally unsuccessful in making a camouflaged American ownership title through the lawyer Oscar R. Seitz.

PHARMACEUTICAL HOUSE OF E. MERCK

Another portion of the report says:

In pharmaceuticals, the most important concern in the world was that of E. Merck, of Darmstadt. This was represented in this country by Merck & Co., a New York corporation which had an enormous and very profitable business in all kinds of medicinal preparations. The stock of this company appeared on the books to be owned exclusively by George Merck, a member of the family which owns the house of E. Merck, of Darmstadt. Investigation, however, showed that the profits of this company had always been remitted to the German house in a manner utterly inconsistent with the apparent stock ownership, and it now stands admitted that the stock was paid for with money of the German house and belongs to the latter. Mr. George Merck insists that he is the real owner of one-fifth of this stock by virtue of the fact that he owns 20 per cent interest in E. Merck, of Darmstadt. I am of the opinion, however, that indirect ownership of this kind cannot be recognized under the trading with the enemy act, and I have therefore determined that the whole of this stock is enemy owned and it has accordingly been taken over.

As there has been 35,400 properties taken over, the estimated value of which is $700,000,000, no attempt will be made to catalogue them. Next in importance and interest will be the action taken with the German owned patents.

CHEMICAL FOUNDATION, INC.

Mr. Palmer explains the German patent transaction as follows:

The idea was accordingly conceived that if the German chemical patents could be placed in the hands of any American institution strong enough to protect them, a real obstacle might be opposed to German importation after the war, and at the same time the American industry might be freed from the prohibition enforced by the patents against the manufacture of the most valuable dyestuffs. Accordingly, these considerations were laid before various associations of chemical manufacturers, notably the Dye Institute and the American Manufacturing Chemists' Association. The suggestion was met with an instantaneous and enthusiastic approval, and as a result a corporation has been organized to be known as the Chemical Foundation (Inc.) in which practically every important American manufacturer will be a stockholder, the purpose of which is to acquire by purchase these German patents and to hold them as a trustee for American industry, "for the Americanization of such institutions as may be affected thereby, for the exclusion or elimination of alien interests hostile or detrimental to the said industries and for the advancement of chemical and allied science and industry in the United States."

STOCK IN A VOTING TRUST

The voting stock is to be placed in a voting trust of which the trustees are to be the five gentlemen who for months have been acting as the sales committee which passes upon sales made by my department, that is to say, George L. Ingraham (former presiding justice of the appellate division, first department, New York Supreme Court); Otto T. Bannard (president, New York Trust Co.); Cleveland H. Dodge; Benjamin H. Griswold (senior partner of Brown Bros., bankers, Philadelphia); Ralph Stone (president, Detroit Trust Co.), and the charter is so framed that under the patents non-exclusive licenses only can be granted on equal terms to all proper applicants, and must be granted to the United States free of cost.

The company is capitalized at $500,000, of which $400,000 is to be 6 per cent cumulative preferred stock and $100,000 common stock, also limited to 6 per cent dividends. The first president of the Chemical Foundation (Inc.) will be Francis P. Garvan, of the New York bar, to whose clear vision and indefatigable industry I am chiefly indebted in the working out of this plan.

COMPANY HAS 4500 PATENTS

By Executive order obtained under the provisions of the act, I have sold to this company for the sum of $250,000 approximately 4500 patents; the remaining $250,000 has been provided for working capital so that the company may be able to commence immediately and prosecute with the utmost vigor infringement proceedings whenever the first German attempt shall hereafter be made to import into this country. The charter of the corporation provides that surplus income is to be used for the retirement of the preferred stock and thereafter for the advancement of chemical and allied science and industry.

The price thus paid was necessarily determined somewhat arbitrarily; the great majority of the patents were presumably valueless. The value of the remainder was entirely problematical and impossible to estimate. Substantially the entire industry having combined for the purpose of this purchase, it would have been impossible on public sale to find as a bidder any legitimate manufacturer. No other bidder could, therefore, have been found on public sale except some speculative individual who might have bought them for purposes practically amounting to commercial blackmail. The combination was not objectionable to public policy since it was so organized that any genuine American, whether a stockholder of the company or not, could secure the benefits of the patents on fair and equal terms.

Fate of the Water-Power Bill

The proposed water-power legislation which has been before Congress for the seven years of the present administration failed of passage when Congress expired March 4. After lengthy debate in committee and on the floor of both houses, conferees on the part of the House and the Senate agreed to report the bill favorably and it would undoubtedly have passed both houses if it could have been reached on the calendar. The proposed legislation did pass the House of Representatives a few days before the end of Congress by vote of 264 to 65, but failed to pass in the Senate, because it became entangled in the meshes of the filibuster which was conducted by Senators opposed to the President's policy in foreign affairs. Although there were informal assurances to Senators who had charge of the proposed legislation that there were at least 80 votes in favor of the measure in case it could be brought before the Senate, the bill did not obtain a hearing.

It will now be necessary for the advocates of water-power legislation to begin a campaign of education for the benefit of the new members of the House of Representatives and the new members of the Senate who are to take their seats in any proposed extra session of Congress which the President may call. Committee assignments which will have to do with water-power legislation will be altered under the organization of the coming Congress. The legislation, which has been in the hands of Democratic leaders in the House, will now be in charge of Republican leaders, inasmuch as the Republicans have control of the new House.

"American Welding Society" to Be Organized

A meeting at the Engineering Societies Building, New York, will be held March 28, 1919, at 10:30 A. M. to effect the organization of the "American Welding Society." It is planned to replace the Welding Committee of the Fleet Corporation and the National Welding Council, and by contributing memberships represent the manufacturers and users of welding equipment and products. Other engineering societies will be invited to participate in such a way that the American Welding Society will become a common section to consider such problems rather than a separate technical organization. To the welding public it hopes to become a dependable source of information, and, granted the necessary support, to pursue various desirable investigations in an impartial manner.

German Requisitions in Poland

The following table taken from the official reports of the German Central War Bureau shows some of the requisitions of the Germans in Poland during the period August, 1915, to the end of 1917, i.e., not including the year 1918, when all their sources were exhausted and when in the latter part of that year they were forced to leave the country and became more unscrupulous than ever:

	Tons		Tons
Metals (among them 7,000 of copper and 910 tons of steel cable)	18,140	Rubber	400
Iron	24,292	Asbestos	105
Prepared leather	1,718	Varnish and oil colors	14
Tanned leather	6,500	Tallow	221
Leather belting	754	Commercial tallow	171
Fat, oils, animal fats, etc.	1,055	Mucilage	215
Oil grains	4,307	Glycerine	40
Oil cakes (poppycakes)	229	Soap	80
		Raw resin	962
		Chemical products	4,168

Magnetic Concentration of Pyrrhotite Ores*

Experiments and Tests Made With a Wetherill Type Magnetic Separator on Pyrrhotite Ore—No Classification Necessary, but Should Be Stage Crushed to Unlock the Sulphides From the Gangue—Costs, Low—Quality, Satisfactory

By J. P. BONARDI
Assistant Chemist, Bureau of Mines

PYRRHOTITE ores have been utilized in the United States for the production of sulphur in the manufacture of sulphuric acid, and when the resulting cinder was sufficiently high in iron and free from objectionable substances it was employed directly in the manufacture of iron. Since the war, the importance of increasing all available sources of material going into acid production has brought pyrrhotite ores and methods of their concentration to the attention of the U. S. Bureau of Mines. The use of pyrrhotite ores in the past was limited, in that a high-grade ore or product was required and also one freed from those gangue substances which would cause trouble subsequently in the sulphur burners, and later would cause the cinder to become penalized in its use for iron smelting. This fact necessitated concentration of some sort, and when hand sorting was resorted to, considerable amount of sulphur-bearing rock was discarded, thus curtailing production and increasing the mining cost.

It was while investigating the pyrrhotite deposits of southwestern Virginia that Mr. R. R. Hornor, of the U. S. Bureau of Mines, observed that much of the ore contained 20 to 30 per cent gangue material, composed chiefly of granular silica and magnesia and lime bysilicates of the amphibole group, together with black mica. The presence of these impurities is objectionable in material for sulphuric acid manufacture for the following reasons:

1. They lower the sulphur content, and considerable quantity of the ore is discarded which will contain around 20 per cent sulphur, thus curtailing production and increasing the mining cost.

2. The capacity of the roasting furnaces is reduced by the quantity of inert material contained in the ore treated.

3. The lime and magnesia present, upon roasting, form sulphates of these minerals and thus reduce the quantity of sulphur available for acid making.

4. The impurities reduce the iron content of the resulting cinder, and also make it less desirable for iron furnaces.

Magnetic Concentration Suggested

It was suggested that the quality of ores containing these objectionable impurities might be very much improved by eliminating a large part of the impurities by some method of concentration; and, therefore, magnetic concentration has suggested itself as possibly the most suited for the purpose, owing to the slightly magnetic properties of the pyrrhotite, and also since the methods which would be employed to prepare the ore for roasting, namely, dry crushing and screening, would obviously leave the material in an ideal condition for magnetic separation.

In accordance with the program of increasing all available sources of sulphur material, it was suggested to the General Chemical Co. of Pulaski, Virginia, producer and refiner of pyrrhotite ores, that it ship large samples of its pyrrhotite material to the Rocky Mountain Station of the U. S. Bureau of Mines for investigation. Two samples of ore were received at this station. One sack consisted of ready crushed material, such as the General Chemical Co. is using at the present time in its roasting furnaces, that is, ore from the finished product bins; the other consisted of large lump size discarded ore from the company's mines.

The following data comprise work done, first, upon the discarded ore, and, second, on the finished product such as the company is now roasting, the object being, in both cases, to attempt to overcome some of the difficulties as outlined above by eliminating the gangue material, and to produce a high-grade concentrate of iron and sulphur from the discarded ore and also from the finished product material. The gangue material in both samples consisted of amphiboles, quartz and biotite.

Discard Ore From the Mine—Part I

The discarded ore as received in large lumps was crushed and finished off in a small "coffee mill" so as to stage crush all material through a 10-mesh screen. A screen analysis of this product through the 10-mesh gave the following results:

—10+20	28.60 per cent
—20+40	34.30 per cent
—40+80	21.00 per cent
—80	16.10 per cent
	100.00 per cent

Since the material was to be submitted for dry magnetic separation, fine grinding was to be avoided as much as possible, as the screen analysis indicates. It has been found by previous work on magnetic separation on roasted pyrite and pyrrhotite material that no practical concentration could be made on screened material which passed through a 100-mesh sieve. When the proper amperage was found which would render the coarse sizes below 100-mesh magnetic, and produce a proper concentrate with the required concentration ratio, it would, when applied to the finer sizes, render them practically totally magnetic; that is, 90 per cent or more, thus effecting no practical concentration of the values, when a concentration ratio of, say, 2 to 1 was desired in order to produce a high-grade product and recovery. This was due to the fact that on such fine ma-

*Published by permission of the Director of the U. S. Bureau of Mines.

terial the magnetic portion would carry off mechanically the non-magnetic fine gangue material.

Five runs were made upon the discarded material, using an experimental type Wetherill magnetic separator having a 6-in. belt and two double pole magnets. One run was made on each of the four screened sized products, and one on the unclassified material as ground, without any sizing, but stage crushed through a 10-mesh.

An analysis of the discard ore, as received and prepared for analysis, gave the following analytical results:

S	19 50 per cent
Fe	33. 45 per cent
Insoluble SiO_2	32 30 per cent
MgO	3 91 per cent
CaO and CuO	Small percentage

The composition of pyrrhotite is represented in text books by:

$Fe_n S_n + 1 \cdot Fe_6S_7$ to $Fe_{11} S_{12}$

1. Fe_8S_7	S = 40. 11 per cent	Fe.....59. 89 per cent
2. $Fe_{11}S_{12}$	S = 38. 51 per cent	Fe.....61. 49 per cent

From the analysis of the discard ore, and considering the proportion of iron to sulphur in pure pyrrhotite, it would indicate that some iron exists in the ore in some other form than is combined in the form of pyrrhotite. Assuming that the total iron and sulphur together make up a magnetic product, there would be represented 52.95 per cent (33.45 + 19.50) of the material magnetic, or a concentration ratio to be obtained for an ideal product of approximately 2 to 1.

Three Ampere Current Adopted

Qualitative runs were first made using different strengths of current by one-half ampere steps from 0.5 ampere to 5 amperes. This was tried on the unclassified material, as well as on the classified screened product, and the results indicated that amperage from 0.5 to 2 would take off only a small percentage of magnetic material. At 2 amperes, the magnetic product was found a little cleaner from gangue material than the product obtained at 2½ or 3 amperes, but the recovery was lower, since a considerable amount of pyrrhotite was still left behind in the non-magnetic tails. Three amperes was finally adopted as the best to employ on this experimental machine from the standpoint of economy and recoveries. At this amperage only a very small amount of gangue, principally biotite, would come off with the pyrrhotite. Higher amperage than 3 took off magnetically a considerable amount of gangue material with a small additional amount of pyrrhotite, which indicated that considerable gangue material was more susceptible to the magnetic forces than the very small amount of pyrrhotite which, in every case, was not attracted by the magnets. Undoubtedly, a slightly higher recovery could be obtained by employing a larger current than 3 amperes, but the grade of concentrate would be considerably lowered by more gangue matter being lifted off with the magnetic product.

The following table indicates the amount of material which was collected as non-magnetic on the different runs at 3 amperes:

Run	Size Stage crushed	Amount Taken	Non-Magnetic	Per Cent Non-Magnetic	Per Cent Magnetic by Difference
I	through 10-mesh	3000 g.	1420 g.	47 33	52 66
II	—10+20	2000 g.	980 g	49 00	51 00
III	—20+40	2000 g.	900 g.	45 00	55.00
IV	—40+80	100	620 g.	62 00	38.00
V	—80	10	320 g.	32 00	68.00

An average of the amount of non-magnetic material in the first four runs would represent 49 per cent, or a magnetic product of 51 per cent, which approximates very closely to the amount as figured as magnetic from the chemical analysis of the iron and sulphur; that is, a concentration ratio of approximately 2 to 1. On the finer size, —80 mesh, 68 per cent would be rendered magnetic, but since this size represents only 16 per cent of the material, the amount of gangue taken off would not in any case prove very detrimental to the grade of concentrate made on unclassified feed; that is, material stage crushed through the 10-mesh.

The following tables represent the runs made; the recoveries are stated later in a separate table:

RUN I UNCLASSIFIED DISCARD ORE AS GROUND THROUGH 10-MESH

Sample	Weight in Grams	Per Cent Insoluble (SiO_2)	Per Cent Iron (Fe)	Per Cent Sulphur (S)	Per Cent MgO
Head	3000	32 30	33.45	19.50	3. 91
Magnetic conc	1440	5.00	55. 85	32. 85	1. 08
Tails	1420	.....	10 85	4. 94	.....
Mechanical loss	140	.....	.....	.....	.....

RUN II —10+20 MESH

Sample	Weight in Grams	Per Cent Insoluble (SiO_2)	Per Cent Iron (Fe)	Per Cent Sulphur (S)	Per Cent MgO
Head	2000	34.20	34 30	19.33	3.04
Magnetic conc	990	5. 20	56.40	32.75	1. 34
Tails	980	.....	5.75	1.71	....
Mechanical loss	30	.....	.....	.....	....

RUN III —20+40 MESH

Sample	Weight in Grams	Per Cent Insoluble (SiO_2)	Per Cent Iron (Fe)	Per Cent Sulphur (S)	Per Cent MgO
Head	2000	29. 70	37. 80	20. 80	3. 15
Magnetic conc	1065	2. 90	60. 80	33. 80	0. 18
Tails	900	.....	10. 28	4. 68	....
Mechanical loss	35	.....	.....	.....	....

RUN IV —40+80 MESH

Sample	Weight in Grams	Per Cent Insoluble (SiO_2)	Per Cent Iron (Fe)	Per Cent Sulphur (S)	Per Cent MgO
Head	1000	34 70	33. 75	17. 98	4 92
Magnetic conc	380	3. 60	58. 08	34. 25	0. 58
Tails	620	.....	14. 38	7. 39	....
Mechanical loss	....	.....	.....	.....	....

RUN V —80 MESH

Sample	Weight in Grams	Per Cent Insoluble (SiO_2)	Per Cent Iron (Fe)	Per Cent Sulphur (S)	Per Cent MgO
Head	1000	29. 80	36. 20	21. 75	3. 11
Magnetic conc	650	19. 80	40. 40	26. 25	3. 22
Tails	320	... .	22. 40	13. 56	....
Mechanical loss	30	... .	.	.....	....

In the above runs, the losses figured as mechanical can be calculated with the magnetic concentrates. This loss occurred at the hoppers in collecting the magnetic material. Whatever loss there was in weight, if any, in collecting the tail discharge would be due only to dust loss, which was of no consequence on the material treated. On continual commercial runs the mechanical losses could be practically eliminated.

In the following table of recoveries of sulphur and iron for the different runs, the basis of calculation was derived by the amount of sulphur and iron remaining in the tails divided by the amount of sulphur and iron going into the heads, which represented the per cent of sulphur and iron going into the tails; the difference between this per cent and 100 per cent gave the recovery of sulphur and iron going into the concentrate.

In calculating the per cent elimination of insoluble (SiO_2) and MgO going into the non-magnetic tails, the per cent remaining in the magnetic concentrates was found (the mechanical loss was figured in as concentrates) and this per cent subtracted from 100 per cent,

giving the per cent of elimination of insoluble (SiO_2) and magnesia (MgO).

RECOVERY OF SULPHUR AND IRON IN MAGNETIC CONCENTRATES
Elimination of Insoluble (SiO_2) and Magnesia (MgO) in Non-Magnetic Tails

Run	Per Cent Recovery of S	Per Cent Recovery of Fe	Per Cent Elimination of SiO_2	Per Cent Elimination of MgO
I Unclassified	88 00	84.65	91 84	84.10
II —10+20	95 67	91.77	82.24	77.55
III —20+40	89.64	87.75	89.75	92.94
IV —40+80	74 50	73.60	96.06	95.56
V —80	80 05	80.20	54 80	29.60

The percentage recovery of sulphur for classified feeds, as in runs II to V if the screen products were run separately as classified feeds, would effect a saving of 84.5 per cent.

The above results clearly indicate that the run made on the unclassified material compares favorably with the screen-classified runs. A slight additional gain in per cent of recovery of sulphur and iron would not in any case be sufficient to install or operate a system of screen classification. Therefore, no classification would be considered justifiable in treating this material on the Wetherill machine.

Conclusions of Results on Discard Ore From the Mine—Part I

1. A high-grade concentrate can be produced from the discard ore from the mine containing less than 7 per cent total of gangue material, consisting chiefly of insoluble matter with a small amount of magnesia oxide, giving a recovery between 85 and 90 per cent of the values sulphur and iron.

2. Approximately 90 per cent of the gangue material can be eliminated with the non-magnetic tails.

3. The concentration ratio between heads and concentrates is about 2 to 1.

Finished Product Ore—Part II

The following data comprise work done upon the ready crushed material or finished product which is being used at the present time in the roasting furnaces, the object of the tests being the same as given with the discarded ore, namely, to eliminate the gangue, since this material also has given some trouble in the sulphur burners in the past due to the same impurities as in the discarded ore, namely, amphibole silicates, quartz and biotite.

The material as received gave the following screen analysis:

+20	23.33 per cent
—20+40	34.66 per cent
—40+60	14.66 per cent
—60+100	11.66 per cent
—100	15.33 per cent
Loss	0.36 per cent
	100.00 per cent

An analysis of the material is as follows:

S	27.51	75.61 per cent
Fe	48.10	
Cu	Trace	
Al_2O_3	2.82	24 39 per cent
SiO_2	12.40	
CaO	0.43	
MgO	1.74	
Undetermined	7.00	
	100 00	

The material was tested for soluble sulphates or sulphur minerals other than sulphides by a sodium bicarbonate and an ammonium carbonate leach, and the results indicated none present.

The above sulphur of 27.51 per cent would then correspond to 41.10 per cent Fe in the first formula as given for pure pyrrhotite (Fe_6S_7) and 43.90 per cent Fe in the second formula as given for pure pyrrhotite ($Fe_{11}S_{12}$), thus indicating that in the material containing 48.10 per cent Fe there must exist some iron in the form of an oxide, which presumably can be calculated with the undetermined portion, or possibly gangue material associated with the other oxides and silicates. Considering the analysis, it is easy to ascertain that if the total iron and sulphur is calculated as being magnetic and the remaining elements as non-magnetic, there would be then represented 75.61 per cent magnetic and 24.39 per cent non-magnetic substances. It is safe to assume that a concentration ratio of approximately 10 to 7.5 will collect the iron and sulphur into a magnetic product with a good recovery.

The following table indicates the amount of material which was collected as non-magnetic on the different sized products at 3 to 5 amperes:

TABLE I.

Run and Amperage	Size	Amount Taken, G.	Non-Magnetic, G.	Per Cent Non-Magnetic	Per Cent Magnetic by Difference
I 3 amp.	+20	2000	445	22.25	77.75
I 5 amp.	+20	2000	200	10.00	90.00
II 3 amp.	—20+40	2000	750	37.50	62.50
II 4 amp.	—20+40	2000	215	9.95	90.05
III 3 amp.	—40+60	1500	470	31.68	68 32
IV 3 amp.	—60+100	1000	310	31.00	69.00
V 3 amp.	—100	1500	70	4.67	95.33
and IX 4 amp.	—100	500	10	2.00	98.00
VI 3 amp.	Original material as received	3000	760	25.33	74.67
VII 3 amp.	Original material as received	3000	895	29.86	70.12
VIII 3 amp.	Material as received with —100 screened out	1200	335	27.90	72.10

From the above data, it is very apparent that 4 or 5 amperes current would be too large to employ, since on the coarse material (20-mesh) 10 per cent would remain non-magnetic, and on the —100-mesh material only 2 per cent would remain non-magnetic; both would be less than was calculated on the percentage of non-magnetic substance in the original material as received. A concentration ratio of 10 to 9 would prove insufficient to eliminate the gangue matter, so 3 amperes was then considered as probably the best to employ in most cases on the material as received and on the sized material, since this would give approximately the desired concentration ratio. In every case tried, 1 ampere proved insufficient, as only a slight amount was rendered magnetic. The following represents the runs made—the recoveries are stated in a separate table:

RUN I +20 MESH—AMOUNT TAKEN, 2000 G.

		Per Cent Sulphur
Head sample		30.85
Wt. of Products, Grams		
2 amperes	330	33.65
3 amperes	945	30.80
5 amperes	245	25.35
Non-magnetic (tails)	200	14.54
Mechanical loss	280	
	2000	

RUN II —20+40 MESH—AMOUNT TAKEN, 2000 G.

		Per Cent Sulphur
Head sample		29,50
Wt. of Products, Grams		
1.5 amperes	295	31.60
2.0 amperes	580	31.10
3.0 amperes	400	31.80
4.0 amperes	510	27.80
Non-magnetic (tails)	215	13.36
	2000	

RUN III —40+60 MESH—AMOUNT TAKEN, 1500 G.

		Per Cent Sulphur
Head sample		27.30
	Wt. of Products, Grams	
1.5 amperes	335	34.97
2.5 amperes	430	33.10
3.0 amperes	250	29.60
Non-magnetic (tails)	470	18.00
Mechanical loss	15	
	1500	

RUN IV —60+100 MESH—AMOUNT TAKEN, 1000 G.

		Per Cent Sulphur
Head sample		26.73
	Wt. of Products, Grams	
1.5 amperes	210	36.70
2.5 amperes	210	32.10
3.0 amperes	245	27.80
Non-magnetic (tails)	310	18.85
Mechanical loss	25	
	1000	

RUN V —100 MESH—AMOUNT TAKEN, 1500 G.

		Per Cent Sulphur
Head sample		26.10
	Wt. of Products, Grams	
2.0 amperes	850	27.50
3.0 amperes	290	25.80
Non-magnetic (tails)	70	22.80
Mechanical loss	290	
	1500	

RUN VI ORIGINAL MATERIAL AS RECEIVED—AMOUNT TAKEN, 3000 G.

		Per Cent Sulphur
Head sample		27.51
	Wt. of Products, Grams	
1.5 amperes	750	32.10
2.5 amperes	960	31.50
3.0 amperes	415	29.20
Non-magnetic (tails)	760	17.43
Mechanical loss	115	
	3000	

RUN VII ORIGINAL MATERIAL AS RECEIVED—AMOUNT TAKEN, 3000 G.

		Per Cent Sulphur
Head sample		27.51
	Wt. of Products, Grams	
3.0 amperes	2050	31.85
Non-magnetic (tails)	895	18.90
Mechanical loss	55	
	3000	

RUN VIII COMPOSITE SAMPLE (+20+40+60+100)—AMOUNT TAKEN, 1200 G.

Weights Proportioned Corresponding to Screen Analysis

		Per Cent Sulphur
Head sample		27.88
	Wt. of Products, Grams	
3.0 amperes	850	31.70
Non-magnetic (tails)	335	18.43
Mechanical loss	15	
	1200	

RUN IX (SAME AS RUN V) —100 MESH—AMOUNT TAKEN, 500 G.

		Per Cent Sulphur
Head sample		26.10
	Wt. of Products, Grams	
2.0 amperes	345	25.50
2.5 amperes	70	27.75
3.0 amperes	35	25.13
4.0 amperes	10	23.75
Non-magnetic (tails)	10	19.50
Mechanical loss	30	
	500	

Efficiency Easily Calculable

The mechanical losses can be accounted for because of the difficulty in collecting all the magnetic products, as some did not fall in the hoppers, also because of some dusting and trouble experienced with the feed box not working properly. The recoveries figured on the heads minus the tails would be representative of the efficiency, as no trouble was found in collecting the non-magnetic portion.

TABLE II ANALYSIS OF NON-MAGNETIC TAILS

Run	Mesh	Per Cent Sulphur	Per Cent Iron	Per Cent CaO	Per Cent MgO	Per Cent SiO_2
I	+20	14 54	18.35	1.15	3.84	59.30
II	−20+40	13.36	14 45	2.11	4 16	54 75
III	−40+60	18.00	27.45	1.58	4.42	36 75
IV	−60+100	18.85	28 25	1.79	5.18	31.30
V	−100	22 80	Not determined			
VI	Original	17.43	26 70	1 70	4.66	35.70
VII	Original	18 90	30.67	1.44	3.48	37.80
VIII	+20+100	18.43	28.55	1 89	4.30	34.90
IX	−100	19.50	Not determined			

Result of Analysis

The analysis was not made on tails of Runs V and IX, because this represented runs made on —100-mesh material; and referring to Table I we see that there was no practical concentration ratio, since at 3 and 4 amperes only 4.67 per cent and 2 per cent respectively remained in the non-magnetic tails. Referring to Table II, it would appear that Run I on 20-mesh material and Run II on —20+40-mesh material gave the best tails, cleaner in sulphur and iron than on the other runs.

However, the analysis on these runs cannot be compared with the others, since the tails were produced by employing as high as 5 amperes on Run I with 10 per cent non-magnetic substance and 4 amperes on Run II with 9.95 per cent non-magnetic material. Also an analysis made on the magnetic products of these two runs show that they are contaminated with more gangue material.

Three Amperes Best for Comparison

The basis of comparing the results obtained on the classified sized material and the original sample is best found at 3 amperes.

Referring to Table I and the analysis of products of the respective runs conducted at 3 amperes, the following table is derived for a basis of comparison.

TABLE III ANALYSIS OF NON-MAGNETIC TAILS

Run		Per Cent Non-Magnetic at 3 Amp.	Per Cent Sulphur in Tails at 3 Amp.	Per Cent Iron in Tails at 3 Amp.	Per Cent SiO_2 in Tails at 3 Amp.
I	20 mesh	22.25	20.49	Not determined	
II	−20+40 mesh	37.50	23.51	Not determined	
III	−40+60 mesh	31 68	18.00	27.45	36.75
IV	−60+100 mesh	31.00	18.85	28.25	31.30
VI	Original mesh	25.33	17.43	26.70	35.70
VII	Original mesh	29.86	18.90	30.67	37.80
VIII	+20+100 mesh	27.90	18.43	28.55	34 90

The above results clearly indicate that at 3 amperes the results obtained on the original material as received compare favorably with the screen-classified runs. Therefore, no classification would be advantageous in treating this material on the Wetherill machine. As was previously stated in this paper, 3 amperes was found best to employ on the discarded ore also.

Recovery Results Tabulated

The following table will show in detail the results retabulated on runs made on the finished product material as received, with the percentage of recovery figured on the sulphur and iron that remained in the tails.

Since the results obtained on unclassified material compared favorably with any of the classified material, only the recoveries on these runs will be considered.

TABLE IV RESULTS OBTAINED ON MATERIAL AS RECEIVED ON WETHERILL MACHINE AT 3 AMPERES

		S	Fe	CaO	MgO	SiO_2	Per Cent Recovery S	Per Cent Recovery Fe
Run VI...	Heads	27.51	48.10	0.43	1.74	12.40	.....	.....
	Conc.	31.20	55.40	nil	0.83	4.30	83.96	86.00
	Tails	17.43	26.70	1.70	4.66	35.70	16.04	14.00
Run VII Duplicate	Heads	27.51	48.10	0.43	1.74	12.40	.....	.....
	Conc.	31.85	35.80	nil	0.94	3.85	80.00	80.97
	Tails	18.90	30.67	1.44	3.48	37.80	20.00	19.03

RUN VI

72.90 per cent of the total silica (SiO_2) remained in the non-magnetic tails
100.00 per cent of the total lime (CaO) remained in the non-magnetic tails
61.90 per cent of the total magnesia (MgO) remained in the non-magnetic tails

RUN VII (Duplicate, run same as VI)

90.60 per cent of the total silica (SiO_2) remained in the non-magnetic tails
100.00 per cent of the total lime (CaO) remained in the non-magnetic tails
59.70 per cent of the total magnesia (MgO) remained in the non-magnetic tails

From the average of the above two runs and the foregoing data, the following can be drawn:

Conclusions for Finished Product Ore—Part II

1. That from 80 to 84 per cent of the sulphur can be recovered, from 80 to 86 per cent of the iron can be recovered to form a high-grade concentrate.

2. That from 72 to 90 per cent of the total silica can be removed, 100 per cent of the lime and about 60 per cent of the magnesia.

3. It is apparent that the gangue that collects in the concentrate is either picked off mechanically, due to the —100-mesh material, or else is more magnetic than the pyrrhotite that remains in the non-magnetic tails.

4. The best working amperage would be between 3 and 5, depending upon the grade and fineness of concentrate; on this particular experimental type machine, 3 appeared the best to employ on the unclassified feed. The concentration ratio is approximately 10 to 7.5.

General Summary

1. The experiments and tests have proved that pyrrhotite ores of the grade received can be successfully treated by magnetic separation. Whether a company is justified in installing several machines depends upon the extent of the ore deposit and the demand for sulphide ore.

2. No classification of the ore is necessary, but it should be stage crushed enough to unlock the sulphide mineral from the gangue. On the ore treated stage crushing through a 10-mesh proved satisfactory.

3. The cost of treating a ton of material which would require no classification would be less than $1, and would possibly approach a few cents, depending upon the number of machines in operation, since one tender and a helper can easily take care of ten machines when in operation. A commercial size machine would probably treat between 5 and 10 tons of material per day. The depreciation of a Wetherill type magnetic separator is very slight, and the cost to operate would be covered by the cost of power going to magnets (3 amperes by 110 volts) and the power for motor operating machine. The capacity of any magnetic separator depends upon so many variables that it is impossible to estimate the exact tonnage until a test run has been made on a commercial size machine.

4. The grade of concentrate produced from the discard ore is superior to the grade received as finished product ore, and is equal to the concentrate obtained after treating the finished product material.

In conclusion, the author wishes to express his appreciation and gratitude to Dr. R. B. Moore, superintendent of the Rocky Mountain Station of the U. S. Bureau of Mines, and Dr. S. C. Lind, acting superintendent, for their valuable advice and instruction throughout the progress of the work.

The Engineer as a Citizen

What promises to be one of the most important meetings ever held by the New York sections of engineering societies will convene in the auditorium of the United Engineering Societies Building, Wednesday, March 26. The meeting has been arranged under the auspices of the American Institute of Mining and Metallurgical Engineers, the American Society of Mechanical Engineers and the Society of Automotive Engineers. The Electrical, Civil and Chemical Engineers as well as the American Chemical and Electrochemical Societies and other related organizations have been invited to participate.

The subject for the symposium is "The Engineer as a Citizen." It will be discussed under five heads, viz.

The Civic Responsibility of the Engineer. Philip N. Moore, A. I. M. E.

The Relation of the Engineer to Legislation. Calvert Townley, A. I. E. E.

The Relation of the Engineer to Administration. Nelson P. Lewis, A. S. C. E.

The Relation of the Engineer to Public Opinion. Spencer Miller, A. S. M. E.

The Relation of the Engineer to Production and Distribution. Comfort A. Adams, A. I. E. E.

National Association for the Protection of American Rights in Mexico

Representative groups of industrial concerns operating or having interests in Mexico have recently organized an association for concerted action to protect their own property and to promote friendly relations between the United States and Mexico. The function of the association will be to collect data regarding conditions in Mexico and be prepared at all times to furnish information to the Government of the United States and the American public. It will endeavor to keep constantly in touch with both Governments and assist wherever possible in removing causes of friction. It is particularly emphasized that the purpose of the association is not to bring our Government into conflict with Mexico but to promote stability in the latter country and confidence in our own. Thus far the association is composed of petroleum producers, bankers and security holders, mining and smelting companies, agricultural and other interests. Business organizations having interests in Mexico are invited to join the association. Mr. Frank L. Silsbee is secretary, and is located at Room 2800, 120 Broadway, New York City.

Work of the United States Employment Service

During the eight weeks ended Feb. 22, the United States Employment Service received 1,090,124 applications from men and women for jobs. Of this number 930,029 were referred to opportunities and 679,513 were reported placed in employment. The difference between the number referred to jobs and the number reported placed is due in a large measure to the failure either of the employee or employer to send in their return cards. Unless these return cards are received, the Service has no record of whether the prospect has received employment or not.

Observations on Flaky and Woody Steel

Discussion of the Causes of This Troublesome Defect in High-Grade Alloy Steels by the Eminent Italian Ironmaster—Methods Are Outlined by Which Flakes and Woody Structure Have Been Brought Under Complete Control in Ansaldo's Works

By DR. FEDERICO GIOLITTI
General Manager of Steel Works, Giov. Ansaldo & Co.

I WAS very much interested in the discussion of flaky and woody structure in steel which took such a prominent part of the recent meetings of the American Institute of Mining Engineers. In Italy we are much interested in such defects, especially at the Ansaldo works, where about two-thirds of the guns used by the Italian Army were made. Our output was expanded many times in the last four years, in the face of a great lack of old and skilled workmen, so that during the war we manufactured more than 10,000 guns, with complete mountings. The defects known as flakes and woody structure have been known to us for some time, and we have done much experimental work which has enabled us to eliminate them almost entirely. The practical result of this experimental work was that none of the gun forgings manufactured in our works have been rejected on account of woody or flaky structure.

Our experience agrees roughly with the last paragraph of the résumé published in CHEMICAL & METALLURGICAL ENGINEERING for March 1, 1919 (page 219), except that we believe they are not formed as cracks in the ingot. Therefore we would state these sentences: "Flakes originate in tender alloy steels as intercrystalline cracks, probably intensified by inclusions and segregations. They can consequently be controlled by careful steel furnace practice, casting, soaking, reheating, forging and heat treating."

Choice of Raw Materials Important

Ansaldo's gun forgings are of acid open-hearth steel exclusively, made from the highest grade pure puddled iron and a very pure electric furnace pig produced in our own furnaces at Aosta from Alpine magnetites. We insist that phosphorus and sulphur be held at an extreme minimum. Of even greater importance, however, we feel that free iron oxide (scale and rust) be kept at the lowest possible point in the raw materials charged in the furnace. This refers to scale on the surface of the metal (rusty turnings and borings are never used) and free oxide in the puddled iron itself. Thus a pure wrought iron will contain considerable iron silicate as intercrystalline streaks which is not detrimental, but an impure Lancashire iron containing free oxide may not be used.

Starting from this pure iron, extreme care is used to prevent superficial oxidation during melting by maintaining a reducing flame in the open-hearth furnace at all times. The slag covering is very thin, consisting only of silica combined with the fluxed impurities in the original iron; it is maintained so that test buttons show a clear glass, of a straw yellow color. We refine very hot; some 20 min. before pouring, shoveling into the furnace sufficient ferrochrome to produce the required analysis. At this time the condition of the metal and slag should be such that very little chromium is lost—one sign of good metal is that a 0.60 per cent chromium bath should produce not less than a 0.57 per cent chromium ingot.

Hot Pouring Preferred in Europe

Contrary to Dr. Howe's recommended practice, we pour very hot. Our forging ingots are all fluted octagons, and our observations show that flakes, when they occur, have no habitual location or direction. The hot steel is cooled to 600 deg. C. in the mold, then stripped and left in the air. The cold ingot is then reheated just before forging to 1200 deg. C. as a maximum and the forging continued to a dull red heat. The large dendritic crystals formed in hot-poured ingots require care and skill in forging, it is true, but when rightly done such steel produces superior results, and so it has become a saying in our plants that when the outer part of hot-poured ingots has a tendency to crack under forging it is a sign of a good heat, and no rejections will occur.

Chromium Steel, Properly Made, Will Not Develop Flakes

What I wish to emphasize is that chromium steel, properly made of pure materials in this manner under reducing conditions and containing no oxide, will never develop flakes. When so made you can pour it into an ingot of any cross-section and forge it as you like—either fast or slow, with reheating or without, with great or slight reduction (always providing the work is done within the correct temperature limits and with usual skill)—and flakes will not appear. We have made a large number of complete experiments to prove this point, using many types of ingots, then forging and treating them in many different ways for making different sizes of gun forgings. I have in my office complete records of these experiments, which I hope to be able to publish later.

As an instance of our contention that, if the steel is properly made, flakes are not produced by mechanical work, I may cite the fact that in November, 1917, after the Austrian advance which cost us so many men and guns, we wished to produce gun tubes at a rate far beyond the capacity of our forging presses. We therefore took our good steel ingots, heated them to the correct temperature and rolled them in a blooming mill, reducing their diameter from about 1.050 m. to about 0.250 m. in this way, without reheating. I do not need to remark that this practice produces intermetallic changes about as different as can be imagined

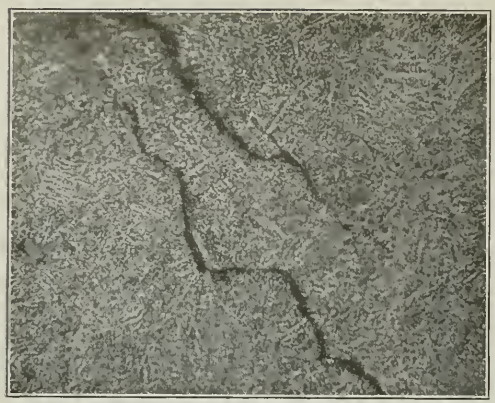


FIG. 1. FLAKES IN HEAT TREATED NICKEL-STEEL FORGING. AFTER RAWDON. × 500

from that by forging, yet not a single instance of woody or flaky structure resulted. After the pipe was cropped off, the balance of the piece was perfectly sound, as was established by numerous tests in all parts of the section. It was then bored and turned to dimension, and the resulting ordnance was satisfactory in all respects.

Oxidized Inclusions Responsible for Flakes

On the other hand, a bath of metal properly made from correct raw materials will develop woody structure excessively if only a few kilograms of scale are thrown into the furnace even a long time before tapping. Microscopic examination of this defective metal seldom reveals an increased amount of inclusions, still we feel that this "oxidized metal" is flaky by virtue of its content of emulsified iron oxide, or some substance produced thereby which has diffused or broken up beyond the detection of a microscope. If rusty scrap or turnings are melted, the chances for rejection are increased enormously. Again, we found trouble as soon as the raw materials available were of inferior grade.

Such experiences as these convince us that flaky and woody structure, which two defects are near relatives, occur in steel containing highly oxidized inclusions. Usually these are beyond the power of the microscope to detect, yet sometimes larger non-metallic inclusions are found associated with flakes, as shown by Mr. Rawdon. The action of such larger segregations may be studied, and throw considerable light upon what I regard as the ultimate cause of flakes.

Theory of Cause of Flaking

It is necessary to explain why non-metallic inclusions are often surrounded by decarbonized zones—when this is explained the cause of flaking is also found. It certainly is not due to Ziegler's idea that ferrite, in being rejected from hypoeutectoid austenite, collects around the slag as a nucleus. Crystals usually form about points of like crystalline shape—ferrite grows upon ferrite, or upon isomorphous metallic substances. It seems to me that the presence of ferrite near a slag inclusion is due rather to a decarbonization caused in a manner somewhat like the following:

There exists in slowly cooled clean steel (normalized steel) a considerable quantity of gas in solution, such that a substantial equilibrium exists between the system $Fe : Fe_3C : CO : CO_2$ according to the following equation

$$3Fe + 2CO = Fe_3C + CO_2$$

The gases CO and CO_2 are occluded or dissolved in the metal (among other gases as well) in such a manner that no cavities are found, even ultra-microscopic. A similar equilibrium condition of an oxidizing slag may readily change with changing temperature in such a way that an excess of CO_2 is transferred into the metal, unbalancing the equation given above and shifting it to the left, actually producing a zone of decarbonized iron in that vicinity, somewhat supersaturated with CO gas as well.

In this manner appears a spot of ferrite about an oxidized nucleus. On working, it flattens out into a thin sheet, perfectly continuous with the metal behind it and only separated at perhaps a minute point in the very center. But the flake is not in the real sense an internal crack—the crack with the characteristic bright flaky appearance does not exist until the piece is strained beyond the elastic limit of the surrounding unaffected metal. When this stronger metal stretches it throws a concentrated stress on the weaker ferrite spots, which forthwith fracture.

Discussion of Theory

The following simple experiment is cited to sustain my theory of flake-formation. Take a piece of steel in which decarbonized zones surround a slag inclusion, and heat it to 1000 deg. C. in an atmosphere of CO for some 24 hours. On re-examination, the inclusion is no longer surrounded by ferrite. Again heat the sample, but this time in CO_2, and the ferrite envelopes reappear. In the first case the excess CO in the surrounding atmosphere overwhelms the CO_2 from the inclusion, and the region is carburized; in the second case the preponderance of CO_2 in the slag inclusion is re-established and decarburization ensues.

All these matters have been discussed by me completely in different papers published in 1914 in "Zeitschrift für Metallographie," and in 1916-17 in "Metallurgia Italiana."

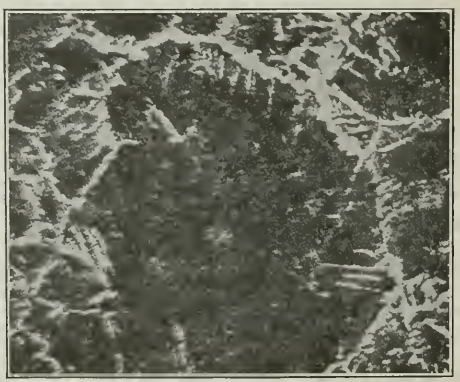


FIG. 2. FERRITE SEGREGATION IN HOLOCRYSTALLINE METAL. AFTER CLAYTON

Mr. Rawdon's sample (Fig. 1) is apparently of quenched metal, and the decarbonization along the flake (which does not need to be very deep-seated) is not in evidence. Should this specimen be annealed, it is probable the crack would then exhibit ferrite borders. Messrs. Clayton, Foley and Laney, on the other hand, showed lantern views where the crack is bordered by ferrite in coarse-grained metal something like the diagonal ferrite streak in Fig. 2. However, as can be seen from the preceding discussion, I differ from Mr. Clayton and his associates in that I believe the ferrite is due to invisible oxidized inclusions; the flake follows essentially these inclusions rather than true ferrite grain envelopes or Widmanstättian bands.

The fact that flakes are not found so frequently in carbon steels would support my hypothesis, since it is a well-known fact that carbon steels (under the same conditions) retain but few non-metallic inclusions as compared with these alloy steels.

Woody Structure Cured by Heat-Treatment

If my gas-theory be true, it should be possible to cure woody structure by heat-treatment, and this has indeed been done systematically in the Ansaldo works when the steel was not actually overloaded with highly oxidizing slag. Such defective material if heated to 1000 deg. C. in reducing atmosphere (largely to prevent surface oxidation) for perhaps 12 to 18 hours, will allow a complete equilibration of the gaseous atmosphere and a ferrite diffusion resulting in a more uniform carbon distribution. As a matter of fact a measure of highest quality in steel is the ease by which structure caused by forging or rolling may be obliterated by heat treatment. (It is easy to show that inclusions are much more important in their effect upon "inheritance" and the appearance of free ferrite than are the original dendrites. Thus a piece of polished heat-treated steel lightly etched with MCl will show the outlines of the original crystalline grains. Repolish and etch with picric acid, and photograph the younger crystals in exactly the same area. Superimpose these micrographs and the older crystalline outlines will appear to have little relation to the younger ones.) These questions are also covered in the papers already noted, and to a greater extent in a volume on "Heat Treatment of Low Carbon Steels," published last year in Italy and now in course of translation into French and English.

Woody Structure Reduced by Light Reduction

Again, woody structure, if not excessive, can be diminished by careful and light reduction at temperatures from 1200 deg. C. to 800 deg. C. The exact explanation of this fact is not clear, except perhaps that forging at low heat destroys Widmanstättian structure, and with it any ferrite cleavages.

My opinion is founded on a careful study of the effect of visible inclusions on the constitution of the surrounding metal, on the mechanical properties of the steel and on the appearance of the fractures. A long account of these observations has been published in the volume already quoted. It may be noted that flakes differing widely in size and extent are associated with visible inclusions of the same size—large inclusions, if non-oxidizing in nature, do not give rise to flakes, while very small inclusions can produce very large flakes if they have a highly oxidizing power. This oxidizing nature is revealed by the large areas of ferrite occurring around the inclusions in the slowly cooled metal.

These interesting and important matters I hope to discuss more at length upon my return to Italy, when I will have our original records and observations available.

New York City.

American Electrochemical Society, New York Meeting

THE program arranged for the American Electrochemical Society, which will convene in New York City April 3 to 5, gives promise of meeting fully the hopes and expectations of those who planned the symposium on "Released Information." Members of the society who have been engaged in important war work of a chemical and electrochemical nature are now permitted to write and talk about the processes on which they have been working. The sessions will be held in Rumford Hall, Chemists' Club.

The annual business meeting and election of officers will take place Thursday morning, April 3, and will be followed by a technical session for the discussion of papers. The afternoon will be devoted to the same purpose. In the evening there will be an illustrated lecture by Mr. W. S. Landis on the Oxidation of Ammonia to Nitric Acid.

Both morning and afternoon sessions on Friday, April 4, will be devoted to the symposium on "Released Information."

Tentative plans are under way for an all-day trip to the chemical and metallurgical plants at Perth Amboy on Saturday, April 5. With the close of the war social features will be in order again and Section Q will be revived at a smoker.

Following are some of the papers that will be presented:

Oxidation of Ammonia, W. S. Landis.
Notes on Electrostatic Precipitation, H. D. Braley.
A Process for Electrically Refining Nickel, G. A. Guess.
Principles of Inductive Heating With High Frequency Currents, E. F. Northrup.
Uranium, Gustave Gin.
Remarkable Pitting of Electroplating, O. P. Watts.
Electroplating Iron From the Copper Solution, O. P. Watts.
Nelson Electrolytic Chlorine Cell, C. F. Carrier.
Electrolytic Silver and Gold Refining at Perth Amboy, G. G. Griswold.

Symposium on "Released Information"

1. Edgewood Arsenal, W. H. Walker.
2. An Electrolytic Process for the Production of Sodium Permanganate From Ferromanganese, R. E. Wilson and W. G. Horsch.
3. Silicon Tetrachloride, O. Hutchins.
4. Silicon Tetrachloride and Titanium Tetrachloride Smokes, G. A. Richter.
5. Portable Electric Filter for Smoke and Bacteria, A. B. Lamb.
6. The Preparation of Fluorine, W. L. Argo, F. C. Mathers, B. Humiston and C. D. Anderson.
7. Lead Plating of Shell Interiors and Boosters, A. G. Reeve.
8. Electric Furnace Manufacture of Silicomanganese, B. G. Klugh.
9. Electric Furnaces Used in the Production of Essential War Materials, T. F. Baily.
10. Chemical War Secrets and Releasing Manufacturers' Reports, E. Gudeman.

Fusibility of Coal Ash*

The Interior Province Coals as Compared With West Virginia Coals — Relation of Fusibility Tests to Clinker Formation — Interpretation of Fusibility Tables — Tables of Data on Illinois, Indiana, Kentucky, Kansas, Missouri, Oklahoma, Arkansas and West Virginia Coals

By W. A. SELVIG, W. C. RATLIFF and A. C. FIELDNER

THE interior coal province, which includes all of the bituminous coal fields near the Great Lakes, in the Mississippi Valley and in Texas, contains a vast amount of coal which is extensively mined and has been a very important factor in the development of the great manufacturing centers of this region.

While there is a large amount of analytical data available as to the composition of these coals[1], there has been no general survey of the fusibility of the ash from the various coal beds. The fusibility of coal ash is of special interest to the consumer of coal in connection with the formation of clinker due to the melting of the ash constituents of the coal when fired under boilers. The Bureau of Mines is therefore making fusibility tests on the well-known American coals, and this paper gives a summary of such tests on the coals of the interior province, together with a comparison of similar tests on the well-known coals of West Virginia. A previous paper [2] gave a description of the standard gas-furnace method used by the Bureau of Mines in making ash fusibility tests, together with a summary of such tests on West Virginia coals.

Relation of Fusibility Tests to Clinker Formation

It is well to bear in mind that fusibility tests as made in the laboratory are not directly comparable to the conditions existing when coal is burned in a furnace, as in a laboratory test the impurities remaining as ash are intimately mixed, while there is no such uniform distribution when the coal is burned. Fieldner, Hall and Feild[3] have shown that in a laboratory fusibility test various factors have a great influence on the results obtained.

The standard gas-furnace method as used for the tests takes into consideration the different factors influencing the results obtained, with special reference to the atmosphere surrounding the ash during the test. With this method the atmosphere in which the ash is heated is readily controlled by burning an excess of gas, under which condition a reducing atmosphere is obtained by which the iron in the ash is reduced to the ferrous state, which gives the lowest temperature at which clinkering may result. This is of special importance in testing ash from coals of the interior province, as they contain a relatively large amount of iron in the form of pyrite. Consequently, higher softening temperatures may be expected in tests using oxidizing atmospheres by which the iron would be oxidized to ferric oxide, or in tests using strongly reducing atmospheres by which the iron would be largely reduced to the metallic state. In both of these conditions a more refractory and viscous slag is formed than would result if the atmosphere were such as to reduce the iron in the ash to the ferrous state, which gives the most fusible condition.

Analyses of clinkers from boiler furnaces indicated that the conditions were such as to form clinkers in which the iron is present principally in the ferrous state, consequently the values obtained in the laboratory tests are in this respect comparable to the actual fuel-bed conditions, and give the lowest temperatures at which the intimately mixed ash will soften with the formation of clinker.

Interpretation of Fusibility Tables

The tables of fusibility of coal ash tests give the average values for all mines tested in each coal bed. Average values for each mine were computed from the individual samples, which in practically all cases are standard mine samples collected by representatives of the Bureau of Mines, the United States Geological Survey, or by the various State geological surveys, according to the methods used by the Bureau of Mines[4]. A small number of car samples which were considered representative of the output of the various mines are also included.

The number of mines sampled and the total number of samples represented for each bed are given, as it is evident that the greater the number of mines sampled the more representative are the average values for the coal beds. This should be kept in mind, as in some cases the values given for the beds represent only a few mines and are then not truly representative of the coal bed.

The point taken as the softening temperature is that at which the ash when molded into solid triangular pyramids $\frac{3}{4}$ in. high and $\frac{1}{4}$ in. wide at the side of the base, and mounted in a vertical position, has fused down to a spherical lump. Points at which the tips of the cones first fuse and at which the ash become very fluid are also taken and serve mainly as an indication of

*Published by permission of the Director, United States Bureau of Mines.

[1] Lord, N. W., and others, "Analyses of Coals in the United States, With Descriptions of Mine and Field Samples Collected Between July 1, 1904, and June 30, 1910"; Bull. 22, Bureau of Mines, 1913, 1200 pp. (in two parts). Fieldner, A. C., and others, "Analyses of Mine and Car Samples Collected in the Fiscal Years 1911 to 1913"; Bull. 85, Bureau of Mines, 1914, 444 pp. Fieldner, A. C., and others, "Analyses of Mine and Car Samples Collected in the Fiscal Years 1913 to 1915"; Bull. 123, Bureau of Mines, 1917, 456 pp. Parr, S. W., "Chemical Study of Illinois Coals"; Illinois State Geological Survey, Coal Mining Investigations; Bull. 3, 1916, 86 pp.

[2] Selvig, W. A., "Fusibility of Coal Ash From West Virginia Coals"; Chemical & Metallurgical Engineering, Vol. 19, No. 12, 1918, pp. 826-828. For a complete table giving results obtained for each mine tested, see: Selvig, W. A., "Fusibility of Coal Ash From West Virginia Coals"; *Coal Age*, Vol. 15, No. 1, 1919, pp. 12-16.

[3] Fieldner, A. C., Hall, A. E., and Feild A. L., "The Fusibility of Coal Ash and the Determination of the Softening Temperature"; Bull. 129, Bureau of Mines, 1918, 146 pp.

[4] Holmes, J. A., "The Sampling of Coal in the Mine"; Technical Paper 1, Bureau of Mines, 1911, 18 pp.

the viscosity of the melting ash; however, these values are not tabulated in the following tables. The average per cent ash and sulphur, on the dry coal basis, is given as a basis of comparison of the different beds.

Table I gives the various beds of the interior province arranged alphabetically under the different States, with the number of mines sampled, number of samples represented, average softening temperature in degrees F., per cent ash and per cent sulphur on the dry coal basis.

TABLE I. FUSIBILITY OF COAL ASH FROM THE INTERIOR PROVINCE COALS

Region, State, Bed	Number of Mines Sampled	Total Number of Samples	Average Softening Temperature, Degrees F.	Ash in Dry Coal, Average per Cent.	Sulphur in Dry Coal, Average per Cent.
Eastern Region:					
Illinois					
No. 1 Bed	1	6	2110	11 74	4 86
No. 2 Bed	6	15	2010	9 97	3 58
No. 5 Bed	9	27	1990	10 84	3 28
No. 6 Bed	36	160	2160	10 27	2.30
No. 7 Bed	2	13	2050	10 62	2.69
Indiana					
No. 3 Bed	3	11	2090	10 61	4 34
No. 4 Bed	7	30	2390	8 17	1.62
No. 5 Bed	9	29	2130	10 23	3 54
No. 6 Bed	1	5	2040	9 91	2 65
Minshall Bed	1	1	2120	9 60	2.99
Western Kentucky					
No. 6 Bed	1	4	2130	8 81	2.97
No. 9 Bed	20	78	2030	10 53	3.67
No. 10 Bed	2	2	1990	11 99	4 18
No. 11 Bed	7	39	2030	9 57	4 08
No. 12 Bed	3	17	2150	10 20	2.30
Western Region:					
Kansas					
Bevier Bed	2	6	1980	14 83	4 71
Cherokee Bed	3	8	2110	9 42	3.18
Leavenworth Bed	1	3	2020	18 26	5.46
Weir-Pittsburgh Bed	3	7	2010	11 68	5.31
Missouri					
Bevier Bed	16	42	1960	13.47	4 90
Bowen Bed	1	3	1940	13 18	4 61
Cainsville Bed	1	3	1980	12 71	5.78
Cherokee Bed	1	3	2150	7 51	1 97
Jordan Bed	4	12	2010	12 74	4 42
Lexington Bed	14	39	2000	13 48	4 04
Lower Rich Hill Bed	3	8	1940	15 39	5 43
Lower Weir - Pgh. Bed	2	5	1940	10 78	4.45
Mulherry Bed	2	5	1990	14 58	3.18
Mulky Bed	4	9	1940	11 28	5.25
Rich Hill Bed	1	3	1970	15 47	6.12
Tebo Bed	8	23	2040	11 64	4.66
Waverly Bed	1	2	2020	17 43	8 29
Oklahoma					
Dawson Bed	3	3	1920	8 95	3 91
Henryetta Bed	2	2	1980	8 03	1.59
Lehigh Coal Bed	3	15	2150	11 46	4.17
Lower Hartshorne Bed	9	27	2020	6 03	1 43
McAlester Bed	6	28	2180	6 94	1 67
McCurtain Bed	1	6	2110	6 92	0.84
Panama Bed	2	4	2160	6 81	1.46
Stigler Bed	5	5	2050	5.13	1 91
Upper Hartshorne Bed	3	7	2170	6 15	1 51
Arkansas					
Denning Bed	1	3	2200	7 38	2.45
Hartshorne Bed	5	9	2120	11 59	1 40
Paris Bed	1	3	2140	10 12	3 28
Shinn Basin Bed	1	1	2180	10 36	2.23
Southwestern Region:					
Texas					
Santo Tomas	2	2	2580	19 21	1.98

Coals from all the States included in the interior coal province with the exception of Michigan and Iowa are given, there being no available mine samples of coals from these two States when the tests were made.

In order to compare the values obtained for the coals of the interior province with some of the standard coals of the country, values for the coals from West Virginia are given in Table II. Among these coals are some of the highest grade and best known fuels of the country. The coal beds are arranged according to their geological succession, the uppermost beds being listed first. It will be noted that among the softening temperatures given for the beds of West Virginia are values preceded by a plus sign (+). This indicates that the true values are above those given. Ashes which did not fuse at 2830 deg. F., which was the highest temperature attained in the gas furnace method, were heated to 3010 deg. F. in a molybdenum-wire resistance furnace in an atmosphere of hydrogen; hydrogen being used in this type of furnace to prevent the oxidation of the resistance wire. Ashes softening above 2830 deg. F. have such a low iron oxide content that the nature of the atmosphere surrounding the ash cones during the test has little influence on the fusibility. In a large number of samples of ash from the West Virginia coals the ash remained unfused at 3010 deg. F. These values were marked plus 3010 (+3010) and used as such in figuring the average values for the mine from which the average values of the beds were computed.

Discussion of Fusibility Values

In general the softening temperature of coal ash from the various coal fields of the United States ranges from 1900 to 3100 deg. F. For convenience in discussion, the order of fusibility of an ash may be expressed by subdividing this range of softening temperature into three groups as follows:

Class 1, refractory ashes, softening above 2600 deg. F.

Class 2, ashes of medium fusibility, softening between 2200 and 2600 deg. F.

Class 3, easily fusible ashes, softening below 2200 deg. F.

TABLE II. FUSIBILITY OF COAL ASH FROM WEST VIRGINIA COALS

Series, Bed	Number of Mines Sampled	Total Number of Samples	Average Softening Temperature, Degrees F.	Ash in Dry Coal, Average per Cent.	Sulphur in Dry Coal, Average per Cent.
Monongahela Series:					
Sewickley (Mapleton) Bed	1	5	2080	9 61	3 99
Redstone Bed	2	9	2120	6 08	1.95
Pittsburgh Bed	15	63	2170	7 49	2 45
Conemaugh Series:					
Mahoning Bed	4	4	2160	5 62	1.89
Allegheny Series:					
Upper Freeport Bed	1	1	2190	6 17	1.97
Lower Freeport Bed	2	2	2090	9 84	3.14
Middle Kittanning Bed	1	1	2110	10 93	4.06
Lower Kittanning Bed	7	22	+2490	8 48	3 28
Pottsville Series:					
KANAWHA GROUP					
Coalburg (Buffalo Creek) Bed	2	7	+2990	8 94	0 80
Winifrede Bed	3	4	2950	7 83	0.78
Cedar Grove Bed (Thacker Bed)	10	24	+2540	5.96	1 21
No. 2 Gas (Campbell Creek, Island Creek, Upper War Eagle) Bed	6	27	+2680	5 60	0.97
Eagle (No. 1 Gas, Middle War Eagle) Bed	1	3	+2940	4 40	0.77
NEW RIVER GROUP					
Sewell (Davy) Bed	33	95	+2580	4 36	0.66
Welch (Tug River) Bed	1	5	2840	7 41	0.62
Beckley (War Creek) Bed	22	101	+2800	4 82	0 68
Fire Creek (Quinnimont) Bed	3	17	2440	6 26	0.81
POCAHONTAS GROUP					
Pocahontas No. 6 Bed	1	6	2380	2 88	0 70
Pocahontas No. 5 Bed	2	3	+2610	5 45	0 60
Pocahontas No. 4 Bed (Thin Vein Pocahontas)	7	23	+2570	6 27	0 63
Pocahontas No. 3 Bed (Thick Vein Pocahontas)	66	246	2460	4.81	0 60

West Virginia Coals

The West Virginia coals include representatives of all three classes of fusibility. On the basis of the average softening temperature of all mines sampled from each coal bed, it is found that with the single exception of the Lower Kittanning bed, all the beds of the Monongahela, Conemaugh and Allegheny series belong to Class 3. There are, of course, individual mines here and there, as, for example, in the Pittsburgh bed in Marion County, which come in the lower part of Class 2.

Almost all of the mines in the Pocahontas No. 3 bed in McDowell County and half of the mines in Mercer County belong to Class 2. The remainder are in the lower part of Class 1.

The ash of New River coal is largely in Class 1, the Sewell bed averaging over 2580 deg. F., as compared to 2460 deg. F. for the Pocahontas No. 3 bed of the Pocahontas coal. The other important bed of this field is the Beckley or War Creek, having a uniformly refractory ash averaging over 2800 deg. F.

In so far as tested the Kanawha coals comprising the Coalburg, Winifrede, Cedar Grove, No. 2 Gas and Eagle beds also show a very refractory ash. Very little if any clinkering should be experienced in using these coals.

Interior Province Coals

The coals from the interior province present a fusibility survey of entirely different aspect from that of West Virginia coals. With the exception of the No. 4 bed in Indiana and the Santo Tomas bed in Texas all the average fusibility values of the different beds are found between 1900 and 2200 deg. F. Furthermore, the fusibility of ash from different samples taken in the same mine usually shows comparatively small variation, averaging only 140 deg. F. in the mines represented in the table.

The low softening temperature of the ash from these coals is probably due to the pyrite, gypsum and calcite that occur so generally as impurities in coals from the interior province. A few mines producing low sulphur coal in the No. 6 bed of Franklin County, Illinois, belong to Class 2 as regards fusibility of ash.

In general it might be said that individual mines producing lower sulphur coal than the average sulphur values given for the bed in which they occur also gave higher fusibility of ash values than that indicated in the table for the bed.

Fuels Chemical Laboratory,
Pittsburgh Experiment Station,
Bureau of Mines.

Change in Method of Distribution of Bureau of Standards Standard Samples

THE Bureau of Standards reports that it is making strenuous efforts to renew its depleted stock of standard samples. The great increase in the demand for these samples from regular sources and extra calls from the inspection sections of the War and Navy Departments, together with the inability to get increased appropriations for this work, have made it very difficult to keep the supply adequate. The demands of the military branches of the Government have made it impossible to procure the material for the renewal of some of the samples and have made it difficult to procure the machinery for the preparation of the iron and steel samples. It may not be realized generally that the preparation of a Standard sample consumes about three-fourths of the time required for the entire work upon it.

The present method of distribution has been known for some time to be cumbersome. New ordering and shipping regulations have therefore been adopted and ordered published on two additional pages 5 and 6 of the Supplement to Circular No. 25, "Standard Samples—General Information." This new supplement will be ready for distribution about March 15, and can be obtained on request from the Bureau of Standards, Washington, D. C.

As adopted, these regulations provide for the ordering of standard samples by number and name from the list printed on the first page of the above-mentioned supplement just as at present. From this time forward all samples for points in the United States or its possessions will be shipped by parcel post, C.O.D. Those for points in Canada, Mexico and other foreign countries will be shipped by express, C.O.D. The regulations of the Department of Commerce require that the payments for these samples be in the hands of Government agents before delivery can be made. By using the parcel post exclusively the Bureau hopes to make it possible for customers to send in their orders and pay for them through their own post office when delivery is made. It is hoped in this way to make prompter shipments and avoid the necessity for refunds when samples ordered are out of stock.

The 10 per cent quantity discount heretofore given on four or more samples ordered at one time has been discontinued.

The Bureau has on hand at present a fairly adequate stock of the following:

Sample Number	Name	Constituents Determined or Intended Use	Weight of sample in grams	Fee per sample with certificate
1	Argillaceous limestone	Complete analysis	100	$1.00
2	Zinc ore D	Zinc	100	1.00
4b	Iron B	C, Si, Ti, P, S, Mn	150	2.00
5c	Iron C	C, Si, Ti, P, S, Mn, Cu	150	2.00
7	Iron E	C, Si, Ti, P, S, Mn, Cu, Cr, Ni, V	150	2.00
8b	Steel, bessemer, 0.1 C	C, Si, P, S, Mn	150	2.00
9b	Steel, bessemer, 0.2 C	C, Si, P, S, Mn	150	2.00
11b	Steel, B. O. H., 0.2 C	C, Si, P, S, Mn	150	2.00
12b	Steel, B. O. H., 0.4 C	C, Si, P, S, Mn	150	2.00
15a	Steel, B. O. H., 0.1 C	C, Si, P, S, Mn	150	2.00
16a	Steel, B. O. H., 1.0 C	C, Si, P, S, Mn	150	2.00
17	Sucrose	Calorimetric value and saccharimetric value	60	2.00
20a	Steel, A. O. H., 0.4 C	C, Si, P, S, Mn, Cu, Cr, V, Ni	150	2.00
21a	Steel, A. O. H., 0.6 C	C, Si, P, S, Mn, Cu, Cr, V, Ni	150	2.00
22a	Steel, bessemer, 0.6 C	C, Si, P, S, Mn	150	2.00
24	Steel, vanadium, 0.15 V	C, Si, P, S, Mn, V (Ni, Cr, Cu, Mo)	150	2.50
26	Crescent iron ore	Al_2O_3, CaO, MgO	100	1.50
27a	Sibley iron ore	SiO_2, P, Fe	150	2.00
28	Norrie iron ore	Mn (low)	100	1.50
29	Magnetite iron ore (titaniferous)	Full analysis	150	2.00
33	Steel, nickel	C, Si, P, S, Mn, Ni (Co, Cr, Cu, W, Mo)	150	2.50
34	Steel, A. O. H., 0.8 C	C, Si, P, S, Mn (Cu, Cr, Mo)	150	2.00
35	Steel, A. O. H., 1.0 C	C, Si, P, S, Mn (Cu, Cr)	150	2.00
37	Brass, sheet	Cu, Zn, Sn, Pb, Fe, Ni	150	3.00
38	Naphthalene	Calorimetric value	50	2.00
40	Sodium oxalate	Oxidimetric value	75	1.25
41	Dextrose	Reduction value	70 140	2.00 3.00
42	Tin	Melting point	350	2.00
43	Zinc	Melting point	350	2.00
44	Aluminium	Melting point	200	2.00
46	Cement (normal)	Testing sieves	160	.25
47	Cement (extra fine)	Testing sieves	160	.25

There are at present in course of preparation samples Nos. 6c iron D, 13b B. O. H. steel 0.6 carbon, 14b B. O. H. steel 0.8 C, 23a bessemer steel 0.8 C, 25a manganese ore, 30a chrome-vanadium steel, 31a chrome-tungsten steel, 32a chrome-nickel steel and 37a sheet brass.

Of these it is hoped to have Nos. 30a and 37a ready for distribution by April 1, 1919. Nos. 6c and 25a should be ready by June 1 and the others will follow as rapidly as facilities will permit.

Decomposition of Metals—I

A Critical Review of Various Theories Which Have Been Advanced From Time to Time to Explain the So-Called "Disease of Metal"—Allotropy, Recrystallization, Corrosion, and Season-Cracking May Each Be Responsible for Some Types of Such Failures

By COLONEL A. I. KRYNITZKY[1]

CONSIDERABLE popular attention has been attracted lately to the decay or decomposition of metals, although this is not new to technical literature. Thus, Messrs. Moissan and Ditte discussed the question of the decomposition of thin aluminium ware in the pages of *Comptes Rendus de l'Academie des Sciences* in 1898 and 1899. A very interesting study of the same decomposition was made by Ducru about twenty years ago, when he proved that such decomposition or self-destruction is accompanied by but very little chemical reaction or oxidation. Ducru examined under the microscope the parts which were in various stages of disintegration, and in some he noticed a nest of fire cracks. These observations were published later by H. Le Chatelier[2], who, as did Charpy and Heyn, also studied various stages of decomposition of soldiers' drinking flasks.

Ernst Cohen brought these questions to life again in 1910, basing his essay on the work of Dr. von Hasslinger[3]. The latter started his studies with an accidental discovery. He attempted to use a pump which had stood without use for two years, and he found that it could no longer maintain a vacuum. Upon careful examination he found that the tin (the pump was made of tinned iron, soldered) had cracked and had become crystallized in spots. Besides, the whole surface, previously bright, had a crystalline structure and a dull appearance. Hasslinger supposed at first that this was the so-called "gray modification" of tin, stable below 18 deg. C. This idea was disproved, however, by the fact that the temperature of the laboratory had never fallen below 19 or risen above 45 deg. C., as was noted by maximum and minimum thermometers.

"Disease" Communicated

To his great surprise Hasslinger further made a successful attempt to communicate this "disease" from the decomposing tin to some with a clean surface. Such "infected" pieces of tin, when kept at different temperatures (6, 19 and 37 deg. C.), exhibited a similar progressive decomposition, the surface becoming dull and crystalline in appearance, spreading in a circle from the point of infection at the rate of from 3 to 5 mm. a day, the speed decreasing as the distance from the center. Along the edges of such decomposed spots tiny cracks could be seen, and even beyond these cracks the tin was crystallized. The same results were obtained with the infection of tinfoil containing about 25 per cent of lead. In this case the decomposition penetrated the full thickness of the foil and the decomposed part fell to pieces when shaken. High temperature did not affect the condition of the tin until the melting point was reached. Decomposed tin became normal after being melted.

Hasslinger also found that the melting points of the decomposed and normal tin were different: 205 deg. C. for decomposed and 231 to 232 deg. C. for normal material taken not far from the damaged portion. It must be noted, however, that the pieces of decomposed tin could not be absolutely separated from the last traces of the normal metal.

Allotropic Modifications of Tin

It would not be out of place to mention some of the facts known in regard to the allotropic modifications of tin. These were observed by Erdman as far back as 1851. He noticed that tin organ pipes became decomposed in spots without any apparent cause—the surface of the metal became rough, swollen and covered with projections. After a sufficient length of time small grains of metal fell out, so that there finally appeared a hole in the wall of the pipe. Fritzche (Petrograd) described similar cases in 1869 and several others during the period 1870 to 1897. Ernst Cohen described a case where a large part of a billet of very pure white "Banca" tin had decomposed into a gray powder after it had been received in Moscow. The gray modification could easily be scraped off with the fingernail. The writer, together with Eng. Koroboff, observed similar cases with Banca tin in the Petrograd Time Fuse Works.

According to Farup, in the case of cast tin the decomposition may be prevented, or at least considerably delayed, by adding some antimony to the metal. He has shown that the alloying metals may be divided into three groups as follows:

1. Hg.
2. Zn, Cd, Cu, Ag.
3. Bi, Sb.

Mercury is practically inert in its effect. Metals of class 2 have a slight influence, increasing in degree from left to right as they are written. Metals of the third class retard the transformation considerably.

Authorities differ as to the cause of such decomposition. Some attribute it to low temperature; others to low temperature together with shaking or vibration, and some to the decomposition which follows more or less rapid cooling of melted tin. Cohen and Van Eijk found that at about 18 deg. C. white tin transforms into a modification known as gray tin. In other words, there exists at least two allotropic modifications of tin, viz., gray, which is amorphous and has a specific gravity

[1]Member of the Commission for Inspection of the Artillery Orders of the Russian Government and Chief Inspector of Time Fuses.
[2]*Revue de Metallurgie*, 1911, Vol. 5, p. 373: "Etude d'echantillons d'aluminium spontanément désagrégés, remis par M. Ducru."
[3]*Revue de Metallurgie*, 1910, No. 4.

of 5.8, stable below 18 deg. C., and white, which is crystalline, has a specific gravity of 7.2 and is stable at temperatures above 18 deg. C. The transformation was found to be reversible.

Transformation Requires Some Time

The phenomenon of the transformation of white tin into gray—the so-called tin "plague"—is very much like that transformation well known to chemists where brown sulphur reverts into the yellow modification when it is slowly cooled after melting. On account of a certain amount of internal friction the transformation from one crystalline form into another requires some time. Thus the yellow spots which appear on the surface of the brown sulphur grow very slowly. Likewise, when white tin is cooled below 18 deg. C. it does not become gray immediately, but tends to remain as the white modification in an unstable condition. This may be compared with the unstable condition of oversaturated solutions; crystallization (and transformation) ensues on the introduction of a small fragment of the solute (or on contact with a particle of the transformed material).

In addition to the change into amorphous gray tin at 18 deg. C., the tetragonal white crystalline modification stable at room temperature changes into a rhombic modification at 161 deg. C., as was proved by Degens[4], although previous investigations had placed this point at 200 deg. C. Trechman also determined the specific gravity of the rhombic tin to be 6.5 at 15.8 deg. C., while for the tetragonal tin at 15 deg. C. it was 7.2. Rhombic tin is very brittle; this explains a common method of producing tin powder, which consists of dropping tin when heated to about 200 deg. C. from a certain height upon iron plates.

The diagram, Fig. 1, represents different stages of the condition of tin, and graphically represents the following facts: At 18 deg. C. gray tin becomes white (tetragonal); at 161 tetragonal tin becomes rhombic; and rhombic tin melts at 232 deg. C. This cycle is reversible, and the dotted lines *df* and *c* indicate unstable conditions at ordinary temperatures.

Ernst Cohen[5] has carefully studied the allotropy of tin as well as of other metals. He discovered that the infection may be inoculated in tinfoil by means of the decomposed powder in such a way that it will show its effect on several thicknesses of the foil laid one on top of another. Cohen originally thought that he was witnessing simply a transformation of the normal tin with tetragonal crystals to the rhombic modification first described by Trechman and Foullon, as noted just above. This idea was disproved, however, by Hasslinger's temperature test, which showed that when infected tin was kept at different temperatures (7, 19 and 37 deg. C.) it continued to decompose.

A piece of tinned iron was infected in one spot and kept in a thermostat at 184 deg. C. After one-half hour, the decomposition was noticeably spreading further and continued even after twelve hours. The same result was obtained in a thermostat held at 161 deg. C., while uninfected tin did not show any change whatever under the same conditions. Similar tests proved that the progress of the infection was still noticeable at 230 deg. C. (very near the melting point, 232 deg.), so that such decomposition could not have been explained by the transformation of tetragonal tin into the amorphous gray modification.

Recrystallization of Copper and Tin

A new theory had to be advanced, and the following facts were taken as a basis. First, it has been proved that metal becomes more susceptible to electrolytic action if it has been drawn or forged. Forged metal is evidently in an unstable condition as compared with metal not forged. This can be seen from the fact that

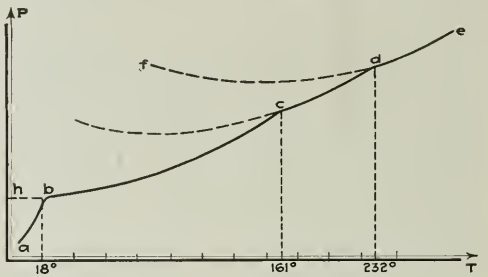


FIG. 1. ALLOTROPY OF TIN

in a galvanic battery composed of the forged and soft metals in a solution of a salt of the same metal, the forged metal becomes charged negatively and passes into solution. It is thought that the transformation of forge-hardened metal into a stable condition takes place even at ordinary temperatures, but at a very slow rate, so that it takes a long time before such transformation can be noticed. It proceeds more rapidly with rise in temperature, and also when the piece is brought in contact with the final (stable) modification.

A very good example of recrystallization was given by Baucke, who made the following experiment. He took two pieces of copper, hammered and annealed, respectively, and clamped their polished surfaces together. The combination was then heated to different temperatures successively, and it was found that at 105 deg. C. the hammered surface became considerably recrystallized. But when the surfaces were separated or insulated with an oil film there was practically no modification even after 48 hours at 180 deg. C.

The second basis for the new theory is derived from the ability of metals to change their crystalline structure. This means that the crystals can grow in size, which, as has long been known, takes place more rapidly with higher temperatures, although it appears probable that previous straining is a prerequisite to crystalline growth. Generally speaking, the following phenomena are included in the term "recrystallization":

1. Change in the form of the crystals (polymorphous crystallization).
2. Growth of small crystals.

[4] *Zeitschrift fur Anorganischen Chemie*, 1909, Vol. 63, p. 207. [5] "Physical Chemical Studies of Tin"; *Zeit. Phys. Chem.* Vol. 30, p. 601; Vol. 33, p. 57; Vol. 35, p. 588; Vol. 48, p 243; Vol. 50, p. 225, Vol. 63, p. 625; Vol 68, p. 214. Also the following on allotropy are important: "On So-called Explosive Antimony," Ibid., Vol. 52, p. 129; "Amorphous Antimony and Bismuth," Vol. 61, p. 588. "On the Metastability of Metals," Ibid., Vol. 71, p. 301; "Physical Chemical Studies of Lead," Ibid., Vol. 74, p. 202. "Atomic Volumes of Allotropic Modifications at Very Low Temperatures," Ibid., Vol. 71, p. 385. "Physical Chemical Studies of Bismuth," Ibid., Vol. 85, p. 419. "Physical Chemical Studies of Cadmium, Copper and Zinc," Ibid., Vol. 87, pp. 409, 419 and 426, although the very careful electrical resistivity measurements of G. K. Burgess and Kellberg do not indicate transformation of copper.

3. Change from an amorphous into a crystalline form.

According to Beilby's theory, it appears that when tin or any other metal is rolled or otherwise deformed beyond its elastic limit, its crystalline structure is destroyed in part.[6] It is possible, therefore, by rolling or forging tin plates to extreme thinness to get almost completely amorphous metal. Such plates can show recrystallization phenomena very plainly at temperatures below the melting point[7]. Heated in a thermostat at 150 deg. C., they become dull in appearance in a few minutes, and in about one-half hour at 110 deg. C. This surface under oblique light appears to be covered with scratches and under a magnifying glass (10: 1) a net-

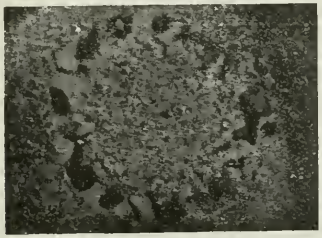


FIG. 2. RECRYSTALLIZED ANNULUS UNDER SPHERICAL DEPRESSION. × 3.8

work similar to that appearing on cast tin may be seen. This difference exists, however, that whereas the cast surface is marked with grooves separating crystalline groups, recrystallization produces a projecting mesh composed of the edges of the newly formed crystals. A study of similar cases with other metals has shown that this is not a new entity forming in the metal, but simply the merging and growth of the fractured and partly destroyed crystals.

Recrystallization of Steel

A very interesting study of the recrystallization of steel was made by Charpy[8]. He produced a depression in a piece of steel by means of a steel ball as is done in a Brinell hardness machine, and then planed this piece until the bottom of the depression was reached. The sample now had a perfectly flat and smooth appearance, but after annealing, the etched surface as viewed under the microscope had developed noticeable traces of deformation, as may be seen in Fig. 2. The large crystals on the periphery form a circle of about 10 mm. diameter, which is that of the steel ball used. Apparently, a critical shear and deformation took place near the center of this ring, which explains the more pronounced recrystallization in this place. Fig. 3 shows a part of the same circle, magnified 100 times. Crystals on the periphery are in the lower part of the picture, and the center of the circle is beyond the upper.

Stead in 1898 had shown that the grains of ferrite develop most rapidly in low carbon steel at temperatures from 650 to 750 deg. C. Charpy proved further that under the same conditions ferrite grains grow more rapidly when the piece had been cold drawn or forged. He took a piece of soft steel, cut it in two, and subjected one end to cold drawing. Then both pieces were annealed at 650 to 800 deg. C. After cooling. each piece was broken in the middle. The fracture showed that the cold-drawn piece had a much larger crystalline structure. When the drawing affected the surface layers only, then large crystals were seen only near the surface.

Microscopic study shows that the difference in structrue of such pieces of steel is only in the size of the grains of ferrite. The relative dimensions of these grains may be quite large, and in fact under favorable conditions of temperature, composition and past history the crystals may grow indefinitely until the whole piece of metal becomes one crystal[9]. This phenomenon is pronounced in the case of low-carbon steel with a certain percentage of phosphorus. The linear dimensions of grains of rolled annealed steel are ten times as large as those in annealed unrolled steel, and the volume, therefore, may be as much as 1000 times as large in

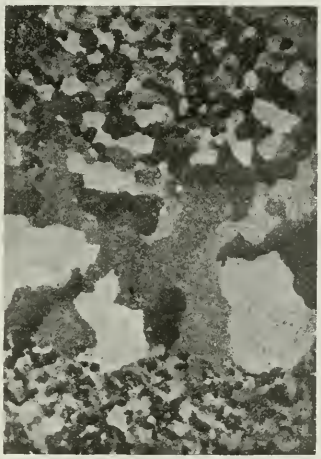


FIG. 3. RECRYSTALLIZATION UNDER SPHERICAL DEPRESSION. × 100

rolled annealed metal as compared to those in annealed unrolled steel.

Such development of crystals causes iron to be brittle. Thus, after the grains reach a certain size, the piece becomes so brittle that the work of breaking an impact specimen becomes almost zero. Charpy observed cases where steel rods, after being cold drawn, could stand considerable hammering without breaking, but after they were annealed at 650 deg. became so brittle that they broke into pieces when dropped on the floor. Every

[6]Beilby's theory of flow and resolidification in a vitreous-amorphous state postulates that layers of molecules many molecules in thickness have the mobility of the liquid state conferred upon them for a brief period; that it is the transient existence of this mobile phase which makes slip and movement among the lamellæ possible and easy and that it is the sudden resolidification of these mobile layers into a non-crystalline or vitreous condition which arrests deformation under a given deforming stress. The original surfaces of any slip are now cemented together by the more rigid material and new surfaces of slip are only developed by higher stresses. The plasticity of the crystalline state is thus gradually used up and the aggregate as a whole becomes more and more rigid. When this has reached a certain stage, further increase in stress leads not to plastic flow, but to disruption.

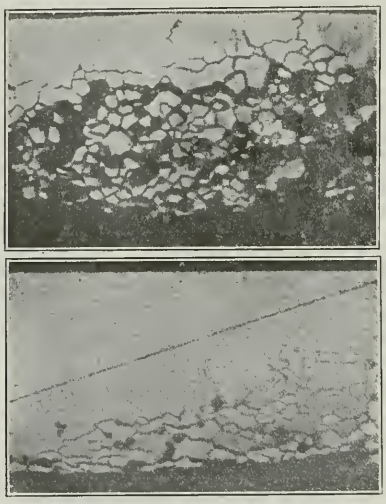
[7]Ewing and Rosenhain discovered that highly compressed lead recrystallized at all temperatures from ordinary up to the melting point.

[8]See also Sauveur's contribution to the Sixth Congress of the International Association for Testing Materials, New York, 1912, Vol. II, p. 6. Charpy, even as far back as 1893, investigated the process of recrystallization and formation of larger crystals in brass and steel under certain heat treatments.

[9]Zay Jeffries, "The Metallography of Tungsten," *Bulletin*, American Institute of Mining Engineers, No. 138, page 1037.

metallurgist can remember such facts from his practice.[10]

Cohen concluded from these considerations that rolled tin must be in an unstable (metastable) condition, and that while the change to a stable condition takes place extremely slowly at ordinary temperatures, it progresses more rapidly at higher temperatures and especially when brought in contact with the stable form. Considering recrystallization as a growth of broken crystals, we can conclude that every cause that may help the growth of crystals at ordinary temperature will also produce Hasslinger's phenomenon of infection more quickly.



FIGS. 4 AND 5. DECOMPOSITION OF SURFACE OF ALUMINIUM FLASK (AT TOP) AND ANODE (AT BOTTOM). × 50

Infection may follow a purely mechanical action: If finely polished tin is hammered obliquely at one place, this spot becomes dull and can "infect" the other tin.

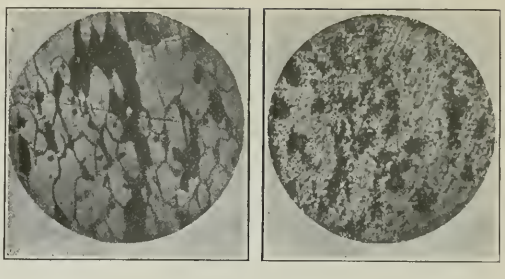
Diseases of Aluminium

The diseases of aluminium described by Ducru were studied further by Le Chatelier. He used microphotography in his work with remarkable success, as can be seen from the accompanying photographs.

Fig. 4, magnified 50 times, shows a section through the bottom of a flask which failed after a short service. The gray-black powder on the surface of this metallic utensil consists, as is plainly shown, of small grains of metal.

Fig. 5, under the same magnification, shows a similar case, except that decomposition is less pronounced. This sample was used as an anode in a solution of sodium chloride. A current of a few milliamperes was applied for a few seconds. The polishing of these samples could be done only after the grains were fixed with melted rosin, which is the dark material separating the white metallic grains. The whole structure has traces of a cellular mesh. One can also notice cracks which are beginning to isolate separate grains of metal.

[10]See Howe, "The Metallography of Steel and Cast Iron," p. 359.



FIGS. 6 AND 7. SURFACE OF ALUMINIUM ANODE AFTER ELECTROLYSIS. × 200

Fig. 6, magnified 200 diameters, shows the same sample electrolyzed for several minutes with a current of 10 milliamperes per square centimeter. Such longer treatment develops the cellular mesh over the whole surface more clearly. The black polygonal depressions indicate places where the grains were torn away. That the metal did not dissolve at these points could be noted from the condition of the electrolyte, which contained many bright metallic specks.

Fig. 7 shows the surface condition of aluminium when treated in the same way, but which has not decomposed. One can see irregular black spots where the metal was corroded by the chemical reaction, but no crystalline structure of missing crystals is evident.

According to Le Chatelier, the decomposition of aluminium may be produced by mild chemical or mechanical action, such as may take place in a utensil over a flame or when containing hot liquids.

Le Chatelier attempted to show the effect of metallic impurities on such decomposition by the following experiments: Aluminium alloys containing 1 per cent of copper, sodium or calcium, respectively, were quickly heated almost to the melting point, and later annealed a long time at 100, 218 and 300 deg. C. At 200 deg. the alloy containing calcium showed something like a mesh-work, but hardly plainly enough to allow any conclusions. With heavily forged aluminium, decomposition may take place by itself, but when heated to 450

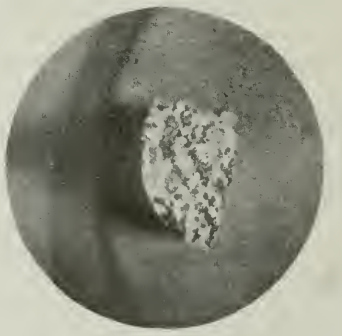


FIG. 8. FRACTURE OF CRYSTALLIZED BRASS ROD. × 1.4

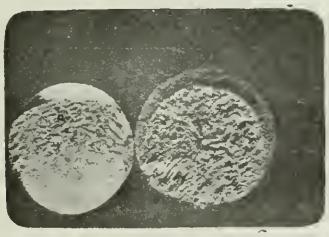
deg. C. these defects disappear. On the other hand, contact with lime water aids decomposition.

Fig. 8 shows a photograph of the break in a piece of brass rod 1¼-in. in diameter, which had been rolled and then annealed. Nothing unusual was observed by the

author about this rod until, after some months' storage, it was dropped, when it broke into pieces. The illustration shows its coarse-crystalline structure—recrystallization.

In 1909 the writer became interested in the experiments with aluminium bronze described by Carpenter and Edwards in the eighth report of the Alloys Research Committee, 1907, and produced several interesting samples in the shape of rods, cast in sand or chill molds, and afterward rolled, annealed and drawn to the required size. The bronze used consisted of 91 per cent copper and 9 per cent aluminium, and the working was all done in the cold. These rods were stored in a room where the temperature varied from about 5 to 20 deg. C. A year later a number of cracks appeared on the surface of some of these rods. Fig. 9 shows a break in a rod which did not have any surface cracks: the break has a uniform velvety appearance. The narrow white stripe shown in the photograph is due to the fact that here the fracture of the rod was considerably higher. Fig. 10 shows a similar break in a rod containing cracks, in a good portion of it between two neighboring cracks. This illustration shows a much more ragged fracture with two distinct zones, a narrow yellow crescent outside encircling the gray-white inside. Fig. 11 shows a fracture from the same faulty rod, but taken through the good portion of it where it exhibited no cracks. In appearance this fracture lies between those of Figs. 9 and 10, the yellow outer circle not being evident. The two black stripes shown on the left and right edges are the traces of the saw cut.

Many other similar cases were investigated with the same result: a large number of "season" cracks being usually accompanied by the more crystalline break, while the yellow circle sometimes covered almost the whole cross-section. Unfortunately the microphotographs



FIGS. 9 AND 10. ON LEFT—FRACTURE OF NORMAL ALUMINIUM BRONZE. ON RIGHT—OF ALUMINIUM BRONZE CONTAINING SEASON CRACKS. × 2

were not distinctive enough to draw many lines of demarcation. Also to the writer's regret it was not determined how cracks were passing—between crystals or across them. According to W. H. Bassett[11] with wrought brasses in the α phase, the cracks always pass between the crystals. H. S. Rawdon[11] in his microscopic exthe cracks pass through the beta. When the alloy is entirely in the β phase, the cracks generally pass across the crystals. H. S. Rawdon[11] in his microscope examination of samples of brass which has season-cracked in some mercury solution found that cracks were intercrystalline; in cartridge brass in which there are only the α crystals, the cracks are truly intercrystalline. In manganese bronze (60-40 brass) the cracks follow, in general, the boundary surfaces between the α and β constituents.

It has been proved beyond any doubt that cold forging and drawing may actually facilitate the decomposition of metals. These facts are characterized by Cohen as " diseases due to cold forging of metals" ("Forcierkrankheit").

Heyn's Limiting Conditions of Equilibrium

In view of the foregoing discussion, it may be stated that decomposition of cold drawn and forged metal is now firmly recognized, but we have yet no satisfactory explanation as to its true cause. Many theories have been offered, and it would be difficult to criticise them,

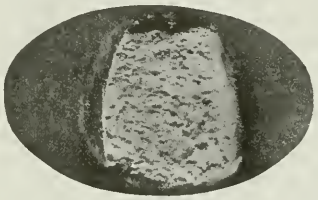


FIG. 11. FRACTURE OF CRYSTALLIZED ALUMINIUM BRONZE. × 2

since, as Heyn said, "Their usefulness may be measured only by their success in opening new scientific horizons and giving fresh impetus for further studies and experiments."

Behrens and Cohen have advanced their theory of recrystallization of metals as described above. The bearing of Beilby's amorphous theory has also been indicated.[12] A most noteworthy explanation of the observed facts, in the writer's opinion, has been offered by Heyn, who suggests that metal during drawing stores up energy, so that overstrained metal has a natural tendency to approach a stable condition which possesses the minimum amount of energy. He therefore controverts Beilby's idea that there should be considered two forms in forged material, namely, crystalline and amorphous, saying that during working the grains get longer and thinner, thus increasing the surface energy of each crystal. Consequently the total energy in the piece also increases, and the action produces an unstable condition in the metal.

Going further, one may assume that along certain surfaces of slip cold work, increased to such an extent that there remain, in consequence of the high degree of splitting up the grains, films consisting almost only of moles or groups of moles, this might be assumed to be a transition of the metal from the crystallized phase into another amorphous phase. According to Heyn, however, it would be more natural to assume that forging develops a thin layer of the same crystalline phase, in which, owing to the cold working, the potential energy is locally raised to a very high figure. In Heyn's opinion, we have to differentiate between "phase equilibria" and the equilibria which are dependent upon

[11] "The Causes and Prevention of Corrosion Cracking," by W. H. Bassett. *Proceedings*, American Society for Testing Materials, 1918, Vol. XVIII, part II, pp. 153-162. "The Use of Mercury Solutions for Predicting Season Cracking on the Brass," by Henry S. Rawdon, Ibid., pp. 189-200.

[12] *Proceedings*, International Society for Testing Materials, 6th Congress, New York, 1912, First Section, II, page 43.

the surface energy. If grains in the metal are split up or stretched by cold work the phase equilibrium remains unchanged, but the equilibrium of the size of grains and of the shape of grains is disturbed owing to the increase of the surface energy. A stable condition is attained only when each phase will have uniform crystalline grains each of such shape and form that the surface energy will be a minimum at all limiting surfaces.

From this standpoint all our metals and technical alloys are in a more or less unstable condition, depending on the size of the crystals and their elongation. The further away they are from the stable conditions, evidently, the more the tendency to approach it. Ordinarily such reversion can take place but partially, as the regroupings of the small grains with high surface energy into large equi-axed crystals of small specific energy become difficult on account of the friction offered molecular movement in the solid. This friction, of course, varies with the pressure and temperature. Consequently, for a given pressure and temperature. there exists an initial degree of equilibrium, which is materially constant.

Heyn defined this as a "limiting state," comparing it with that of a body on an inclined plane, down which it is just prevented from sliding by friction. Therefore, if any factor tends to increase the deformation of the forged metal, then, according to Heyn, this factor also increases the rapidity with which the metal approaches such "limiting state" for the given temperature, pressure and initial degree of stability.

Heyn's theory is a theory of internal strains. He, together with Bauer, even developed a method to determine the amount of such stresses, which may reach a considerable value, exceeding sometimes the ultimate strength, for instance, in forged pieces of nickel-steel, brass or delta metal. These strains disappear after proper annealing at given temperatures. According to the latest researches, they disappear even at comparatively low temperatures.

At the same time, nevertheless, all factors such as additional stresses due to mechanical forces, to irregular heating and cooling, to washing, cleaning, chemical treatment or vibrations tend to increase the decomposition.

According to P. D. Merica and R. W. Woodward,[13] "The welding or burning-in of castings or other articles will also generally produce initial stress in the cooled piece, the welded portion being in tension parallel to the surface and perpendicular to the weld. If a round bar of brass is suddenly cooled by quenching from a high temperature, the outer half of the cross-section will be left in longitudinal compression, the inner half in tension. Measurements have shown that in 1-in. round bars of naval brass and manganese bronze quenching from 450 deg. C. into water produces an average longitudinal, initial compressive stress over the outer half of the cross-section of 14,500 lb. per sq.in."

Investigating the cause of the frequent splitting of the thin steel pipes used in evaporating and precipitating potassium and sodium carbonates, Stromeyer[14] noticed that these cracks appeared only in places where the pipes were subjected to tensile forces. He then prepared specimens, each of two rings, of which the outer one was forced under pressure over the inner one so that the inner one was under compression, with the outer one under tension. These double rings were placed in a solution of sodium carbonate under the same conditions as obtained in the commercial apparatus, and he found that the outside ring cracked, while the inside remained intact. Unstressed rings also remained unchanged.

Heyn cites these interesting experiments conducted by Stromeyer, and points out that some particles in forged metal may be under unbalanced tension as compared with the tension of other particles. Similar strains exist within certain limits in metals subjected to cold shearing. It is interesting to note that somewhat similar stresses were described and explained by Professor D. Tchernoff in his report to the Imperial Russian Technical Society in 1884. He studied the stresses which appear after cold punching or shearing of steel plates and noted that they spread in waves, increasing the elastic limit of the material in the crests of the waves. This phenomenon is known as the "Lüders-Tchernoff lines." Some years later (1895) it was described also by Captain Hartmann. It must be noted, however, that Tchernoff's lines were first observed and described in 1860 by Lüders, who gave them a different explanation[15].

New Process for the Manufacture of Sulphonic Acids

The Department of Agriculture announces that the Color Laboratory of the Bureau of Chemistry, Department of Agriculture, has developed on a laboratory scale a new process for the manufacture of certain sulphonic acids. This process, as carried out in the laboratories, appears so promising that it is thought that some manufacturers of chemicals and dyestuffs in this country may be able to supply their demands for these and other valuable compounds by this process, provided the process can be reproduced upon a technical scale so as to obtain results commensurate with the laboratory investigations. The process refers particularly to the sulphonation in the vapor phase of benzene, naphthalene and other hydrocarbons.

With a view to helping the chemical industry of this country, the Department of Agriculture announces that it is ready to assist manufacturers who wish to produce these compounds. The expenses of the technical installation and of the labor and materials necessary will of necessity be borne by the firm, individual or corporation wishing to manufacture the products. The chemists of the Color Laboratory will assist with expert advice, etc. The Department reserves the right to publish all the data obtained from the technical experiments. This offer of assistance will not be held open by the Department for an indefinite period.

[13] "Initial Stress and Corrosion Cracking," by P. D. Merica and R. W. Woodward. *Proceedings*, American Society for Testing Materials, 1918, Volume XVIII, Part II, pp. 165-178.

[14] *Journal*, Iron and Steel Institute, 1907, I, p. 200; 1907, III, p. 86; 1909, I, p. 404. *Proceedings*, Institute of Civil Engineers, 1886, Vol. 84, p. 144; 1888, Vol. 93, p. 89.

[15] "Ueber die Aeusserung der Elasticität an Stahlartigen Eisenstäben und Stahlstäben, und über eine Celm Biegen Solcher Stäbe beobachtete Molecularbewegung," von W. Lüders, *Dingler's Polytechniches Journal*, 1860, Heft 1, Tages 18-22.

Temperature Uniformity in an Electric Furnace*

A Method of Manufacturing Laboratory Electric Furnaces Producing a Uniform Temperature From End to End of Core—Three Independent Heaters in Addition to End Plugs—Alternate Layers of Insulating and Conducting Materials to Distribute Heat

By JOHN B. FERGUSON

THE problem of temperature uniformity in an electric furnace is intimately connected with almost all investigation carried on at high temperatures. For this reason it has generally been considered as a part of a larger problem and has been solved to the extent demanded by the requirements of the work at hand. In the present paper the writer wishes to discuss the conditions essential for a proper control of the temperature distribution, and the previous attempts that have been made to attain these conditions; and to describe in detail a type of horizontal furnace which he has found suitable for investigations requiring a uniform temperature over the range from 620 to 1190 deg.

General Discussion

The maintenance of a region of uniform temperature in an electric furnace requires that full compensation be made for the heat losses at all points within this region, and the ease with which such a compensation may be obtained is an inverse function of the magnitude of these heat losses. This is not, however, the only factor to be considered in determining the insulation required by any given furnace. If a uniform temperature is to be obtained this insulation must be thick enough to render negligible the effect of non-uniformity in the temperature of the furnace surroundings, and if, further, a constant uniform temperature is to be obtained the insulation must also be of such thickness that fluctuation in this external temperature with time will be without effect. In the former case alternate thin layers of a good conductor and a good insulator may be used to advantage to replace thick layers of a slightly poorer insulator, giving the same uniformity of heat losses but with much reduced lag effects.

The heat losses are never uniformly distributed in a furnace, and the heat supply must likewise be non-uniformly distributed. If the heat losses are of different magnitudes but all similarly dependent on the furnace temperature (an unusual case) a non-uniform heater could be constructed which would afford a compensation over a range of temperatures; but if these losses are not similarly dependent on the furnace temperature (the usual case) then such a non-uniform heater would provide a compensation at one temperature only. In this latter case, if a compensation is desired over a range of temperatures, the single non-uniform heater must be replaced by as great a number of independent heaters as there are indpendent heat losses.

The ordinary electric furnace in which a column of air is heated is the best known example of a region with non-uniform heat losses and is the type the writer wishes particularly to consider. In such an air column, provided convection is eliminated, there will always be a short region having a fairly uniform temperature. The length of this uniform temperature region will be dependent upon the length of the furnace, and for some work a furnace sufficiently long to provide a suitable region of uniform temperature can be used without further attention to end conditions. But the usual problem confronting an investigator is to increase the length of this region without increasing the length of the furnace. The introduction of insulating plugs or baffle plates will cut down the end losses by conduction and radiation and will give a result similar to that obtained by lengthening the furnace. For this purpose a plug of good insulating material is much less efficient than a composite plug made up of good and poor conducting layers, the first of the former being on the inside of the plug next the region to be uniformly heated. Such a plug has two functions: (1) to reduce the end losses by insulating the region, (2) to distribute the heat losses and also the heat supply uniformly across the plug and thus take full advantage of the heating effect of the ends of the heater. This latter precaution is particularly important in furnaces of large diameter.

In many cases the region to be heated uniformly is such a large portion of the whole air column that even composite plugs are inadequate and in this case the simple uniform heater has to be discarded. A specially wound heater designed to give an increased heat supply at the furnace ends will increase the length of the region of uniform temperature and will yield a maximum length at one particular temperature, since with the materials at our disposal the average furnace must be so constructed that the relation of the heat losses to the furnace temperature varies. The use of a furnace of this type is naturally limited, since it is difficult to design a heater that will give the maximum length to the region of uniformity at a predetermined temperature. Special and separate end heaters independent of the main heater offer the most practicable solution, as they enable one to obtain equally good compensation over a range of temperatures.

In designing such a furnace the thickness of the layers of good and poor conducting materials employed will depend on the conditions under which the furnace is to be used and the degree of uniformity required. In general a horizontal furnace gives a better temperature distribution than a vertical furnace of the same dimensions. Two reasons may be given for this: (1) The convection currents in the air column of the vertical furnace are more active and may be considerable if the furnace is not gas tight; and (2) the temperature

*Republished from *Physical Review*, Vol. XII, No. 1.

distribution over the outside of the vertical furnace is much less uniform than in the case of the horizontal furnace. The horizontal furnace has therefore been much more frequently used and was the type employed by the writer.

Almost all investigators in the field of high temperature have been obliged to consider the problem of temperature uniformity. In this paper it is obviously impossible to present all the results that have been obtained and the writer has chosen to present only the work which best illustrates the points he desires to emphasize. In fairness to those quoted the reader should remember that most of them were interested in the development of a furnace suitable for their particular need and in that alone.

Previous Work

Among the earliest investigators to touch upon this problem were Holborn and Day,[1] who in 1899 experimented with both uniform and non-uniform heating coils. They found that the latter gave the better temperature distribution but with an optimum uniformity for a short range of temperature.

A somewhat more complicated furnace was used by Waidner and Burgess[2]. It consisted of two concentric furnaces, the outer having a long heater with crowded end windings while the inner was shorter and uniformly wound. In such an arrangement, the end and center heat supplies are only partially independent of each other and so the compensation is still a function of the temperature, although not as dependent on it as in the case of the single non-uniform coil. These conclusions are entirely borne out by their results.

In 1908 Day and Clement,[3] confronted with the same problem that had confronted Holborn and Day in 1899, were able with a new furnace to obtain along their gas-thermometer bulb a temperature distribution which did not vary over 1 deg. up to 1200 deg. This they did by means of independent auxiliary end heaters which, like the main heating coil, were wound (one in each end) on the inside of the furnace tube and were separated from the main coil by a layer of refractory magnesite cement.

Two slightly different types of furnace were used by Day and Sosman[4] in continuing the work of Day and Clement in 1910. Both had baffle plates in the unused portions of the air column which cut down the end losses by radiation. These end radiation losses, which seem to have been overlooked by all the previous investigators, were found to be of considerable magnitude. The furnaces differed only in the form of the heaters. In the first, the main heater was slightly crowded at the ends and inside wound, while the end coils were similar to those used by Day and Clement. In the second, the heating coil was divided into three units subject to independent control, and was wound on the outside of a thick tube of good conducting material. This second furnace yielded the better temperature distribution but could not be used at the highest temperatures.

The three-heater principle first used by Day and Clement was also employed by Gray,[5] who desired the greatest uniformity attainable. Instead of separating his good conducting baffles by air as Day and Sosman had previously done, he used a layer of a good insulating material. This type of plug, though very similar in principle to the plug used by Day and Sosman, is probably better, since it is a better longitudinal insulator. The fact that metal baffle plates separated by thin layers of air form, in effect, a composite plug conducting transversely and insulating longitudinally apparently did not occur to Gray, who independently later developed the idea. His first furnace, in addition to such plugs, contained thick-walled iron tubes and was heated by three independent heaters; the main heater was of basket weave; the other two were situated in the outer portion of the plugs. Evidence of severe local heatings led him to rebuild the furnace with two concentric heaters of basket weave and larger end coils which now were placed outside of the plugs and covered a considerable portion of the furnace ends.

Gray did not fully appreciate the value of the independent heater idea[6] and attributed his success mainly to other causes. His description implies that such plugs as are described above will enable one to use a furnace with crowded windings over a range of temperature. This is generally true, for if the windings

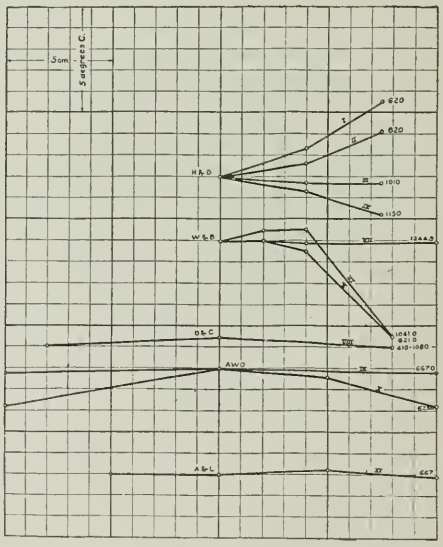


FIG. 1

Curves I, II, III and IV: Uniformity attained in a furnace with crowded ends by Holborn and Day. Curves I and II indicate an over-compensation, and Curve IV indicates an under-compensation of the end heat losses. Curves V, VI and VII: Distribution obtained by Waidner and Burgess at different temperatures. Curve VIII: Results of Day and Clement obtained by means of a furnace with three independent heaters over a range of temperature. Curves IX and X: Results obtained by A. W. Gray. IX shows the temperature distribution with composite plugs and end coils and X with plugs alone. Curve XI: Results of Allen and Lombard.

[1]Holborn and Day, *Ann. d. Phys.*, LXVIII, 815, 1899; *Am. J. Sci.*, (4), 8, 165, 1899.

[2]*Bull.* Bur. Standards, 3, 165, 1907.

[3]Day and Clement, *Am. J. Sci.*, (4), XXVI, 405, 1908.

[4]Day and Sosman, *Am. J. Sci.*, (4), XXIX, 93, 1910.

[5]*Bull.* Bur. Standards, 10, 451, 1914.

[6]In his discussion of this subject, Gray apparently overlooked the various investigations in connection with high-temperature thermometry, for he says: "Previous experimenters have tried to secure uniformity of temperature in an electrically heated air column by using the central portion of a long tube and by crowding the windings near the ends or other places where the heat was lost most rapidly," whereas several of the investigators referred to had already used independent end heaters.

are crowded so as only partially to compensate over the range of temperatures at which the investigator wishes to work the additional compensation may be obtained from the end heaters and a good temperature distribution will result. It will not be a convenient furnace to work with, however, as will be discussed later. But if the furnace is so wound that at any temperature within the range of temperatures considered a perfect compensation is made without the end coils, then at higher temperatures there will be under-compensation and at lower temperatures over-

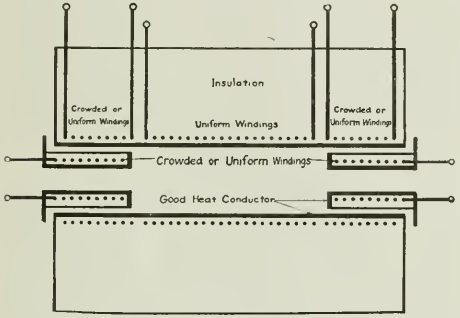


FIG. 2. IDEAL SECTION OF CYLINDRICAL FURNACE WITH INDEPENDENT END HEATERS AND PLUGS

compensation by the crowded ends. Obviously, if there is over-compensation a plug by means of which the supply of heat at the ends can only be kept constant or increased offers no possibility of a solution. The basket weave would seem to have been a detriment rather than an aid, since a single main heater of that type was insufficient and two were necessary to avoid severe local heatings.

The form of the plugs is not as important as would appear from Gray's experiments. The main requisite is the separation of the heaters from the region to be heated by sufficient material to smooth out any local

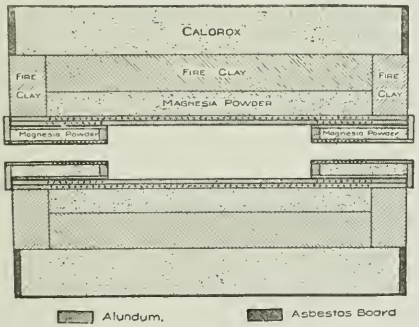


FIG. 3. CROSS-SECTION OF CYLINDRICAL FURNACE WITH END HEATERS AND PLUGS, SHOWING DETAILS OF CONSTRUCTION

heating effects. Just how much latitude there may be in the designing of plugs, end coils, etc., may be gathered from the work of Allen and Lombard[7] and also that of the writer. The furnace of Allen and Lombard had flat end coils that did not cover the plugs, and also solid asbestos caps, while the main heater was a single coil wound on a helically grooved alundum tube with walls 0.5 mm. thick. With this furnace a uniformity equal to that obtained by Gray at approximately the same temperature was obtained. In Fig. 1 curves representing some of the work referred to are given.

[7] *Am. J. Sci.*, 43, 175, 1917.

Experiments

The actual design of any furnace is dependent on the purposes for which it is intended and the materials and facilities the experimenter has at hand. It is therefore doubtful whether any special design will have a very general application.

Nevertheless a description of a furnace may furnish the prospective designer with much useful information, and for this reason a description of a 45-cm. furnace capable of uniformly heating a region 6 cm. in diameter and 10 to 12 cm. long at temperatures ranging from 1000 to 1200 deg., and maintaining this uniform temperature constant for long periods of time, will be given. In the development of this furnace a number of types were tested out, and of these a few proved satisfactory. The final changes were made with the intention of

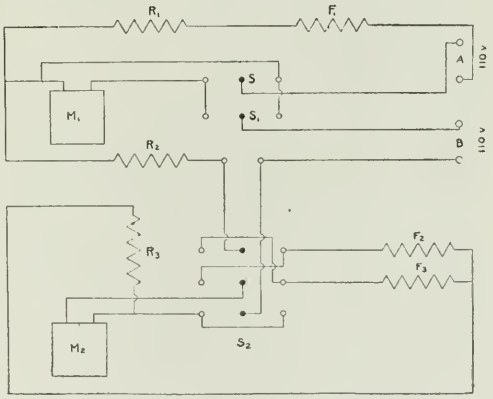


FIG. 4. A CONVENIENT PLAN OF ELECTRICAL CONNECTIONS FOR THE FURNACE WITH INDEPENDENT END COILS

simplifying the construction and regulation rather than of improving the temperature uniformity, since the latter could be obtained in several of the furnaces.

The final design is shown diagrammatically in Fig. 2. The end coils may be either crowded or uniformly wound, but the main central heater must be uniformly wound. Equally good compensation will result if the central heater has slightly crowded winding, but the resulting furnace is not as convenient to use over small ranges of temperature. For example, with a uniformly wound heater at a given temperature changes of ten degrees or so in the furnace temperature can be obtained by regulation of the central heater current without disturbing the compensation much, whereas in a central heater with crowded end windings, the same change in the current would have necessitated considerable adjustment of the end coil current. The end coils should be more closely wound than the center, thus increasing their resistance and lessening the danger of severe local heatings. The heaters are shown as independent units. This

renders possible a variety of connections. In some of the writer's work the tube to be heated was very short and it was therefore desirable to heat the ends as little as possible. Satisfactory results were obtained by running the plug coils in series with the center coil and compensating by means of the end coils. In practically no experiments was a good compensation obtained by running the two end coils in series, as one end invariably required more current than the other.

The actual furnace is shown in Fig. 3. The large amount of insulation was necessary in order that a

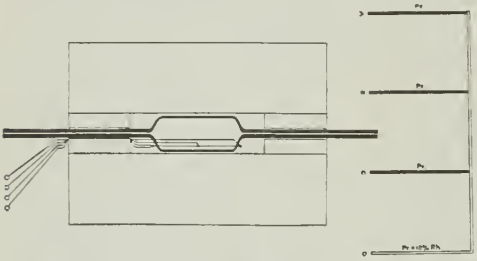


FIG. 5. SECTION OF FURNACE WITH GAS BULB AND COMPOUND THERMO-ELEMENT

FIG. 6. COMPOUND THERMO-ELEMENT

constant temperature might be maintained over long periods of time. The construction of the heater and plugs may be thus described:

Heater.—Two helically grooved alundum tubes were selected of such a size that the smaller readily slipped inside the larger and was of 6 cm. inside diameter. A coil of 0.8-mm. platinum wire was wound on each end of the smaller tube for a distance of 10 cm. from the ends, and the whole was covered with alundum cement and baked. When hard the excess alundum was removed until this tube would just slide into the larger tube. A hole was bored through the large tube at each end at the inner edge of the end coils, and the inner wire ends, which had purposely been left long, were brought out through these holes. The smaller tube was then slid into the larger and these ends drawn tightly through and then wound back on the outer tube to its ends. The central portion of the outer tube was then separately wound with similar wire and the whole covered with alundum cement and baked.[8] This peculiar method of winding was found to be necessary because alundum cement is not as good an electrical insulator as many suppose. Two furnaces, constructed with uniform main heaters extending the full length of the tube and with end heaters wound around the main heater and insulated from it by 0.5 cm. of alundum cement, did not even survive their trial heats, as the current arced from the main to the end coils, burning them out.

Plugs.—The principal details may be observed in Fig. 3. The inner and outer alundum tubes were cemented to an alundum disc with water glass. The space between the tubes was filled with freshly ignited magnesia powder to within 1 cm. of the end and this magnesia held in place by means of a paper washer. The remainder of the space was filled with alundum cement and the whole baked. In order to insure a good tight fit the outer alundum tube was usually coated with alundum cement, and when this had hardened the plug was filed down until it would just slide into the furnace. The inside of the outer edge of each alundum disc was covered with asbestos wool stuck on with water glass, thus insuring a tight fit when the plug was pushed home and eliminating any radiation losses through the crevices.

The use of alundum with burnt magnesia and fireclay in all the hot portions of the furnace assures consistent results from the furnace day after day even at quite high temperatures with practically the same current. The calorox which forms the outer insulating layer is unsuitable at temperatures as high as 1000 deg. The outer shell is of sheet iron, painted with aluminium paint. We find that this paint reduces the total heat losses by reducing the radiation, thereby increasing the temperature of the shell and decreasing the temperature gradient across the insulation.

Electrical Connections.—As has already been stated, the exact method of making electrical connections will depend on the particular use that is to be made of the furnace. Three separate electrical controls will be almost always essential, although the current required by the end heaters will usually be very nearly of the same magnitude. The writer was able to take advantage of this fact in developing a set-up whereby all the adjustments could be obtained from two main circuits with

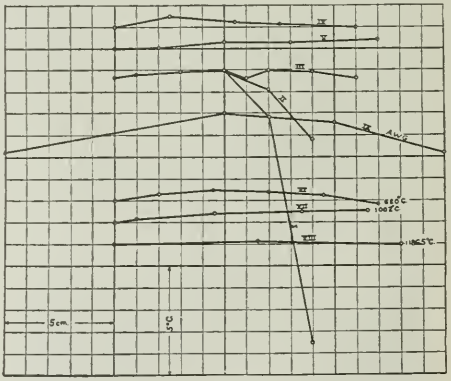


FIG. 7. TEMPERATURE UNIFORMITY

Curve I: Furnace with end plugs and uniformly wound heater. Curve II: Furnace with end plugs and crowded end windings on heater. Curve III: Furnace with flat end heaters similar to those used by Allen and Lombard, with slightly crowded windings on ends of main heater and with plugs. Curve IV: Furnace similar to III with exception that the furnace heater was uniformly wound and the plugs contained extra end heaters. Curve V: Furnace as described in detail in the text. (Curves I-V at approx. 1000 deg.) Curve VI: Furnace V at 620 deg. Curve VII: Furnace V at 1002 deg. Curve VIII: Furnace V at 1186.5 deg. Curve IX: Curve VII of Fig. 1 repeated. When compared with Curves I and II, in which likewise only unheated end plugs were used, an idea may be gathered of the adverse conditions under which the writer worked as compared with those of Gray.

considerable saving both of current and the operator's time.

A diagram of these connections is shown in Fig. 4. *A* and *B* are the two main circuits. In *A* the current always flows through the furnace coil F_1 and the variable resistance R_1 and can be made to pass through the ammeter M_1 by means of the switch S. In *B* the current has two routes, depending on the way the switch S_2 is

[8] A smooth (1-cm. thick) alundum tube upon which the end coils might have been more closely wound than the center would have been easier to handle, but unfortunately was not available.

thrown. As in *A*, the current always passes through a variable resistance R_2 and at will may be made to pass through M_1 by means of switch S_1. The function of the three-way switch S_2 is to place the variable high resistance R_3 in parallel and the ammeter M_2 in series with one of the furnace coils, either F_2 or F_3, at will. If the switch S_1 is thrown to the left and the switch S_2 to the right the current follows the route S_1, M_1, R_2, F_2, R_3 in parallel with F_3 and M_2, and back. The upper ammeter shows the total current, i.e., current through F_2, and the lower the current through F_3. With this arrangement the current through F_3 will always be equal to or less than the current through F_2 but by reversing the switch S_2 the position of these furnace resistances is reversed and so all the required adjustments can be made. If nearly the same amount is required through both F_2 and F_3 the amount wasted in R_2 will be very small.

Temperature Measurements.—In the earlier work a single platinum-platinrhodium thermoelement tube was used. It was mounted in a Marquardt porcelain thermoelement tube having two small holes bored in the closed end, through which the wires passed; the junction was bare and bent so that it would come in contact with the gas balloon which was to be maintained at constant uniform temperature. The thermoelement tube could be inserted or withdrawn from the furnace and the measurements were always made when the tube was about to be withdrawn, since on inserting the tube the uniformity was somewhat disturbed. When the local heatings were found negligible this thermoelement was replaced by a compound element of the form shown in Fig.6, by means of which direct or differential temperature measurements could be obtained at any one of three points with but four leads. Fig. 5 shows one of these later set-ups. At 1000 deg. no trouble with leakage was experienced, but at 1200 deg. it caused considerable trouble, especially whenever any part of the element came in contact with the hot alundum

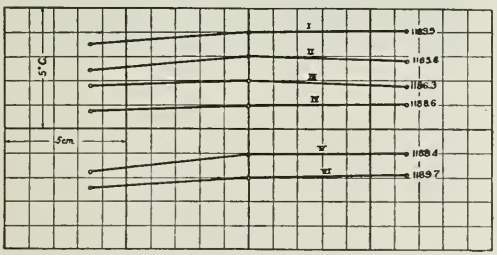


FIG. 8. TEMPERATURE UNIFORMITY. THESE CURVES REPRESENT THE FURNACE DISTRIBUTION OBTAINED DURING A SERIES OF EXPERIMENTS AT APPROXIMATELY 1190 DEG.

furnace tube, and necessitated careful shielding in the furnace itself. This was obtained by placing in the furnace a sleeve of thin platinum foil connected to the outer shield, and carefully insulating the same from the element itself by enclosing most of the latter in Marquardt porcelain. The measurements were made by means of the usual potentiometer set-up.[9]

[9] W. P. White, "Potentiometer Insulation, Especially for High Temperatures and Thermoelectric Work," *Physical Review*, XXV, 334-352, 1907.

In most of the investigations no greater uniformity than ±0.5 deg. was necessary and no attempt was made to improve on this. The apparatus is undoubtedly capable of producing a uniformity of ±0.2 deg., the limit set by local heatings, provided the experimenter is willing to take the trouble with the current adjustments.

Figs. 7, 8 and 9 are curves representing the results. Unfortunately furnace V was not used with the same set-up on different days, so that no comparison can be

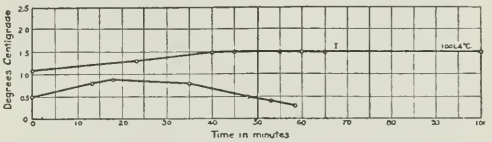


FIG. 9. TEMPERATURE CONSTANCY

Curve I: The fluctuations in the furnace temperature with time in part of a four and a half run with furnace IV at 1001.4 deg. Curve II: The fluctuations in the furnace temperature with time in a run with furnace V at approximately 1190 deg.

made of its performance on different days with the same current. At 1190 deg. with a porcelain tube 3 cm. in diameter at the center and somewhat smaller ends the current required on 110-volt circuit to give a uniformity of ±0.5 deg. was: Left, 5.65; center, 5.50; right, 5.55 amp. Furnace IV was constructed of exactly the same material as furnace V although of different shape, and one may with reasonable certainty infer that if furnace IV would reproduce a given temperature uniformity furnace V would also. Table I gives the results obtained in four separate runs with furnace IV.

TABLE I.—ENERGY REQUIRED UNDER DIFFERENT CONDITIONS OF END RADIATION

Set Up	Date	Left Coil, Amp.	Center Coil	Right Coil	Temperature Distribution
Porcelain tube *A*..	Dec. 7, 1915	3.35	5.1	3.30	1001.0 ± 0.5°
	Jan. 6, 1916	3.35	5.1	3.35	1000.4 ± 0.5°
Transparent silica tube *B*.....	Feb. 21, 1916	4.04	4.95	4.06	1000.0 ± 1.0°
	Mch. 15, 1916	4.05	5.02	4.06	999.5 ± 1.0°

Particular attention is directed to the great difference in the current required by the end coils in the two different set-ups. The heat lost by radiation through a transparent silica glass capillary tube of 1-cm. outer diameter and 1-mm. bore necessitated the increasing of the current in the end coils from 3.35 to 4.06, an actual increase of 0.71 amp., or 21 per cent, and confirmed the observation of Day and Sosman on the magnitude of the end radiation heat losses.

Summary

The production of temperature uniformity in an electrically heated air column can best be accomplished by means of three independent heaters in addition to end plugs. The entire region to be heated should be surrounded by a layer of conducting material sufficient to smooth out any local heatings, and the whole furnace should be so insulated that the effect of non-uniformity in the temperature of the furnace surroundings is rendered negligible. The use of alternate layers of good and poor conductors will reduce the total amount of insulation necessary, but if constancy of temperature as well as uniformity is desired the insulation must be of such thickness as to eliminate the effect of temperature fluctuations in the furnace surroundings during the period the furnace is in use. This type of

furnace has the advantage that it may be converted into a simpler type if less uniformity is adequate by merely changing the mode of connecting the heaters.

A furnace embodying these principles is described in detail. This furnace yielded a temperature uniformity of ±0.5 deg. at temperatures ranging from 620 to 1190 deg.. and at 1000 and 1190 deg. a temperature constancy of ±0.25 deg. for periods of time exceeding an hour. With greater care in adjustment a uniformity of 0.2 deg. should be possible, and without doubt the furnace could be run at much higher temperatures without great loss in efficiency. The furnace is economical of current and will reproduce practically the same conditions on different days with the same amount of current provided the temperatures are below that at which magnesia powder begins to pack.

Some results indicative of the behavior of several different furnaces and set-ups are presented for their comparative value and also with the view of indicating the magnitude of some of the effects obtained.

Geophysical Laboratory, Carnegie Institution of Washington, Washington, D. C.

Exports of Glycerine in 1918

The Department of Commerce, through the Division of Statistics, gives out the following figures of the exports of glycerine to all countries during the calendar year 1918:

Countries	Lb.	Value	Countries	Lb.	Value
France	3,100	$2,530	Dominican Republic	1,476	$1,145
Italy	12,133,339	6,163,011	Argentina	512	354
Norway	50	35	Bolivia	2,515	2,001
Portugal	100	72	Brazil	1,493	998
Spain	56	38	Chile	10,121	7,134
England	6,575,725	3,728,718	Colombia	4,026	3,115
Scotland	246,795	144,354	Ecuador	1,552	968
Ireland	224	161	British Guiana	2,495	1,859
Bermuda	50	38	Dutch Guiana	120	101
British Honduras	46	41	Paraguay	20	18
Canada	1,851,937	1,107,249	Peru	2,886	2,309
Costa Rica	403	289	Uruguay	1,050	723
Gautemala	1,209	930	Venezuela	5,412	3,583
Honduras	441	376	China	7,667	5,562
Nicaragua	677	511	Chosen	87	24
Panama	3,653	2,392	British India	1,480	1,007
Salvador	954	718	Dutch East Indies	105	73
Mexico	13,331	10,645	Hongkong	200	143
Newfoundland and Laborador	400	279	Japan	831,768	540,016
Barbados	450	321	Other British Oceania	2	2
Jamaica	250	197	French Oceania	28	23
Trinidad and Tobago	1,158	817	Philippine Islands	10,503	6,664
Other Brit. West Indies	270	214	British South Africa	7,885	6,066
Cuba	25,516	17,959	British East Africa	35	20
Danish West Indies	175	71	Portuguese Africa	27	15
Dutch West Indies	221	168	Total	21,754,728	$11,766,636
French West Indies	227	185			
Haiti	506	394			

Imports of Platinum Into the United States

The following table shows the imports of platinum into the United States during the fiscal year ended June 30, 1918, by countries of origin:

Country	Unmanufactured Troy Oz.	Value	Ingots, Bars, Plates, Etc. Troy Oz.	Value	Vases, Retorts Value
France	166	$18,142	814	$78,674	...
Netherlands	...	...	...	...	$165
England	1,073	80,834	357	29,614	...
Canada	76	7,249	253	23,671	1,682
Panama	372	35,254	...	...	...
Mexico	9	749	...	...	...
Cuba	...	...	3	260	...
Brazil	27	2,312	...	...	...
Chile	3	300	...	...	...
Colombia	25,365	2,112,211	1,665	129,533	700
Peru	3	300	...	...	...
Venezuela	162	12,960	...	...	...
China	489	38,207	...	...	...
Russia in Asia	21,000	2,000,000	...	...	...
British South Africa	...	...	25	2,344	...
Total	48,745	$4,308,518	3,117	$264,096	$2,547

Improved Treatment of Burns

THE war that has so recently closed has been no exception to those of the past in that all the medical and surgical arts were most intensively developed. Notable among the successes was the treatment of burns by Barthe de Sandfordt, who had spent sixteen years in trying to overcome the prejudices of the medical fraternity to his closed wax seal treatment. It was only when the hospital at Issy les Moulineaux was filled with many patients suffering with burns that it was considered advisable to depart from the usual practice and prove out this method experimentally.

The paraffine wax composition, called ambrine by de Sandfordt, is sprayed on the wound at 140-150 deg. F. and then absorbent cotton is plied on alternately with wax layers. The aggregate of wax and cotton seals the wound and thermally insulates it as well, the temperature of the ambrine at the skin being found to be 106 deg. F. for several hours after each 24-hr. dressing. This method is actually a case of incubation, wherein the flesh and skin cells propagate themselves in a most remarkable manner. However, all infection and bacteria must be excluded if present by some such means as Dakin's hypochlorite solution with Carrel's technique, or the incubation of flesh and skin cell destroying bacteria will result, with the balance sheet showing nothing but loss. Fresh burns, being sterile, of course are ideal for the ambrine treatment, and it has been with them that the most marvelous cures have been made.

The warm dressing has an additional virtue in that it draws the fire instantly from the wound and allows the patient to become normal. Dr. R. C. Casselberry treated the 75 employees burned at the Essington, Penn., powder explosion and reported the advantages of the embrine treatment as:

Relief from pain to a great degree.
Cleaner and more comfortable.
Fewer scars and contractions.
Skin grafting rare.
More rapid healing.
Superior in every way to other methods commonly used.

The Army surgeons have had such marvelous success with ambrine in treating all sorts of burns that it became necessary to establish the Ambrine Laboratories, 347 Madison Ave., New York City, to supply the demand. All manufacturing plants dealing with hot materials and having frequent burn accidents will do well to become acquainted with the results reported in the current medical literature.[1]

British Import Restrictions

On March 4, the War Trade Board announced that individual import licenses were required for the importation of dyestuffs into the United Kingdom. The list included all synthetic dyes, intermediates and color lakes, in paste, powder, solution, or any other form.

Later it was announced that, for the present, general licenses will be granted for the importation of products covered by the prohibition if they are of bona fide French, American or Swiss origin. These licenses will be modified as domestic manufacture develops, so that only essential colors and intermediates will be permitted to enter the country.

[1]Surgery, Gynecology and Obstetrics, Vol. XXVI, No. 4. Page 450, April, 1918, "Treatment of Burns," Dr. W. O. Sherman.

Production of Hydrogen and Water Glass by the Silicol Process

SEVERAL years ago George F. Jaubert described[1] the military methods in use at that time for the production of hydrogen, among which the reduction of water by silicon was of chief importance for military purposes such as for dirigibles, etc. Siemens and Schuckert were the original investigators and worked out a process[2] for the production of hydrogen from the reaction:

$$Si + 2NaOH + H_2O = Na_2SiO_3 + 2H_2$$

Initially steam was employed, but later it was found that the heat of solution of the caustic was sufficient

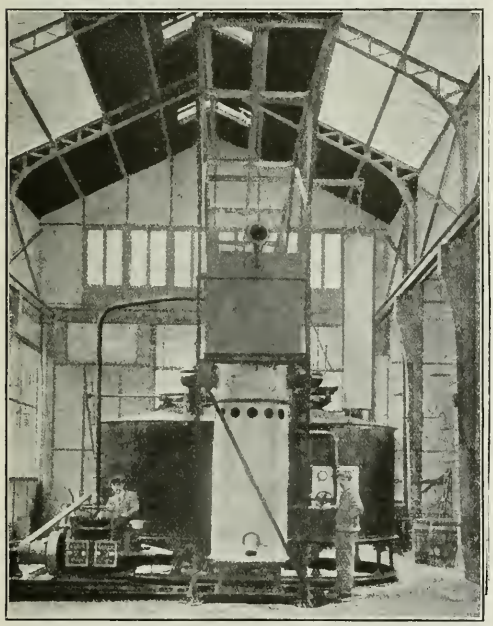


FIG. 1. GENERAL VIEW OF THE BRITISH ADMIRALTY HYDROGEN PLANT

to start the reaction and that it would maintain itself thereafter. The process was a chemical success, but due to the high price of silicon, was not economical.

In order to reduce the costs of the pure silicon, Captain H. Lelarge substituted silicon alloys in the process, successfully operating the reaction with a silicon iron containing as little as 18 per cent silicon. However, the 50 to 80 per cent ferrosilicons were much preferable. *Engineering* in its Jan. 24 issue gives a description of one of the British Admiralty hydrogen gas plants, the production of which in peace times may be utilized in oil refining by the water-glass method and hardening by hydrogenation, offering an outlet for both the sodium silicate and the hydrogen at abnormally low costs.

The plant operates the silicol process, which consists

[1]Memoires et Compte Rendu des Travaux de la Société des Ingenieurs Civil de France, Vol. 11, 1911, pages 45-107.

[2]Brevet francais Nos. 406,930, 1910.

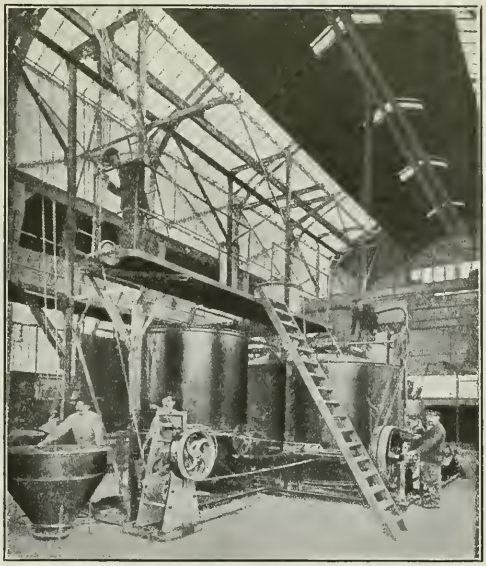


FIG. 2. PUTTING SODA IN THE HOPPER

in the decomposition of silicon alloys obtained in the electric furnace, such as ferro- or mangano-silicon, or even silicospiegel, by a concentrated solution of caustic soda (35 per cent to 40 per cent of NaOH). In the silicol process, the silicon alloys are made to act on a caustic alkali solution having a high boiling-point, the object being to retain in the solution itself all the heat

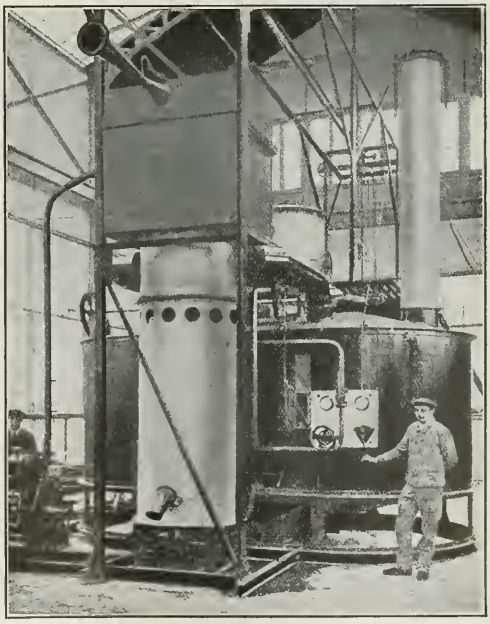


FIG. 3. WATER GAGE AND VALVE OPERATING GEAR

generated by the reaction in the combination of the silicon with the alkali, thus doing away with all outside heating.

The installation contains a vat provided with a stirring device for preparing the caustic soda solution. The lower part of the vat is fitted with a pipe provided with a valve and ending in a gas generator; the latter is fitted with a "planetary stirrer," and has at its top part a receiver containing the silicon alloy. The receiver has a hopper-shaped base in which acts a distributor worked by a crank.

The plant operates as follows. Soda in lumps, in pieces of cylindrical shape or in slabs, is put in a vat, to the extent of one and a half times or double the weight of soda to that of water; the stirring device is started running and the dissolution of the soda takes place, the heat thereby evolved being sufficient to raise the temperature to about 60 deg. or 80 deg. C. The solution is then led into the gas generator, which it should reach at a temperature sufficient to start the reaction on contact with the silicon alloy. The "planetary stirrer" causes the silicon alloy powder falling from the hopper-shaped base of the receiver to come into intimate contact with the caustic soda solution, and prevents it from accumulating in the center of the generator. The hydrogen gas, which is evolved at a high temperature, flows into a scrubber-condenser, where it loses the water vapor it contains and is cooled at the same time. The hydrogen gas then flows out through a pipe for utilization. Fig. 2 shows the soda being put into the hopper shown to the left of the view, the hopper being then raised and placed in the vat. Fig. 3 shows the water gage; Fig. 4 the starting of the water pump, and Fig. 5 the turning of silicospiegel preparatory to its utilization in the silicol process.

The water used for cooling the gas in the scrubber-condenser, which leaves this at a temperature close upon

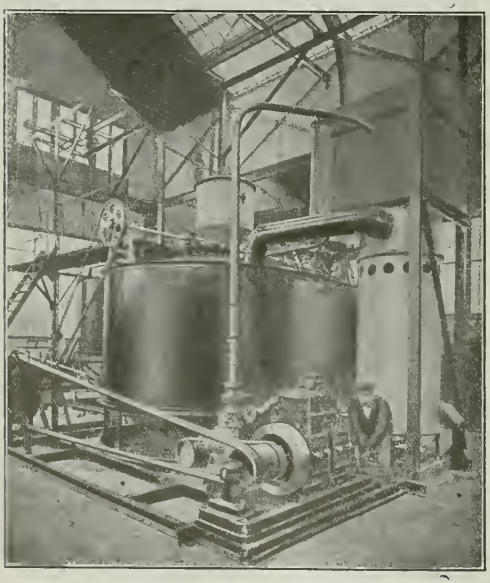


FIG. 4. STARTING THE WATER SUPPLY PUMP

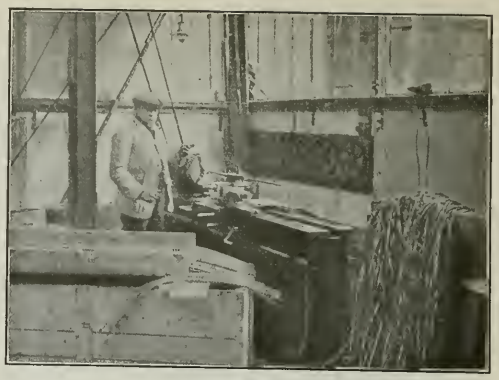


FIG. 5. TURNING THE SILICOSPIEGEL FOR USE IN THE PLANT

boiling-point, is recovered, and is utilized in the vat or in the gas generator as needed.

The advantages of the silicol process lie in the use of a silicon alloy in which the cost of the unit of silicon is a low one compared with that of the industrially pure silicon hitherto used for the same purpose, this leading to a great reduction in the cost price of the hydrogen gas. In installations where a weak solution of caustic soda is used, a neutral silicate of soda is formed, while when working, as is the case in the plant we illustrate, with a concentrated solution, an acid silicate poorer in soda is obtained; this leads to a saving in caustic soda and allows the obtaining of non-caustic residues which can be utilized for dyeing and bleaching.

The water-gage can be suitably connected to the powdered silicon alloy distributor so as to cause the delivery of the alloy powder to vary automatically with the consumption. The alloys which have given good results are the various grades of ferrosilicon, manganosilicon and silicospiegel. One single silicol plant of the type referred to can fill in half a day the largest type of dirigible, producing at the rate of 60,000 cu.ft. per hour.

As the silicol process was considered initially to be limited to military work, no patents were taken out in the United States by the inventors. The time limit has now expired and there is no doubt that full advantage of this economical process will be taken by many oil refiners. Hydrogen has been found to be a most satisfactory sweeping gas for deodorizing purposes, not having the tendency to hydrolyze the oil and thus giving a sweeter product than can be obtained with superheated steam. In producing neutral oil with water glass, the foots separate readily and give an excellent soap powder stock, sufficient bicarbonate being added to destroy the excess water glass content and produce a fine silica grain filler.

The process often may prove economical in plants where only the hydrogen is consumed and the water glass sold in the vicinity. By recovering a larger part of the caustic soda with a mercury cell, the process might be made cyclic. The diminished alkali content in the water glass would be advantageous for most purposes, especially in oil refining.

Fuel Economy in the Boiler House—III*

A Description of the German Types of CO_2 Recorders Which Depend on Measurements of the Physical Properties of Flue Gases—Thermoscope, Arndt's Gas Balance, Krell, Telezometer, Haber-Loewe Refractometer Instruments—Checking Recorders With Orsat Apparatus

By J. B. C. KERSHAW

ALTHOUGH the CO_2 thermoscope is neither continuous nor recording in its action, it may be briefly mentioned here, for the principle upon which it is based is capable of application to a recording type of apparatus. The instrument is shown in Fig. 1, and depends for its action upon the heat generated when carbon dioxide gas is brought into contact with dry caustic soda, the chemical reaction which ensues leading to a generation of heat which is proportional to the percentage of CO_2 contained in the gas sample. The instrument consists of a cylinder fitted with a plunger, by means of which a definite and measured volume of the gas from the flue is drawn into the cylinder. This gas is then forced by the downward movement of the plunger through a small cartridge containing dry pulverized caustic soda. A thermometer is placed on the instrument with its bulb so constructed that it forms a jacket to the caustic soda cartridge, and therefore records accurately the amount of heat generated. A movable scale is attached to the inside of a slot in the cylinder, and by the aid of this the percentage of CO_2 is read off directly.

The Arndt Gas Balance or "Econometer"

In Fig. 2 is illustrated the Arndt gas balance or "econometer," which, as its name implies, is designed for the purpose of weighing the waste gases which pass to the chimney, the record obtained being a continuous and not an intermittent one. If placed in a conspicuous position in the boiler house, the variations in the weight, and therefore in the percentage of CO_2 in the gases, can thus be easily seen and noted. The action of the Arndt gas balance is based upon the known fact that carbonic acid gas is one and a half times heavier than air, the respective weights of one liter being 1.97 and 1.29 grams. An increasing percentage of CO_2 in the waste gases will therefore be indicated by an increase in their density, and if there be no moisture present, the variations in density may be employed as index of the CO_2 contents of the gases.

The method of operation of the instrument is as follows: The gases are drawn continually from the flue at *E*, by means of the steam jet *D*. On their way through the apparatus they pass first through the filter *A* and drying tubes *B*, and then through the weighing bulb *C*. The scale of the balance is graduated so that the percentage of CO_2 can be read off directly, and if it is desired the instrument can also be provided with a recording attachment of the usual type, so that a permanent record of the variations can be obtained.

*The previous articles appeared in Chemical & Metallurgical Engineering, Vol. 20, No. 4, Feb. 15, 1919, and Vol. 20, No. 5, March 1, 1919.

The Krell CO_2 Recorder

Fig. 3 shows the Krell CO_2 recorder, which is closely allied to the Arndt gas balance in principle, although in this case a very delicate differential pressure gage is employed to determine the difference in weight of measured volumes of the flue gas and air. This gage is attached to two columns of equal height, the one containing air and the other the sample of flue gas. The pressure gage readings are taken by means of a slightly inclined glass tube, filled with colored alcohol, which projects from the side of the gage box or case. The height of this thread of colored alcohol varies with the pressure, and by means of a scale, marked in the percentages of CO_2 corresponding to certain pressures, the amount of this constituent if the flue gas can be read off at any time. The apparatus is usually provided with accessories by means of which the position of the end of the thread of colored liquid is continuously photographed on a recording cylinder, and thus a permanent record of the CO_2 variations is obtained.

The Telezometer Recorder

The principle upon which the Telezometer recorder is based is similar to that of the Krell recorder—the variations in pressure caused by the differences in density of the ordinary air and of the flue gases being measured and recorded. The gases in this case are drawn by two centrifugal fans worked by a constant speed electric motor, through the bells marked 1, 2, 3 and 4 in Fig. 4. In this figure the bells are shown diagrammatically floating in separate vessels, but in the real instrument 1 and 2 are immersed in one tank, and 3 and 4 in another, paraffine oil being employed as containing fluid.

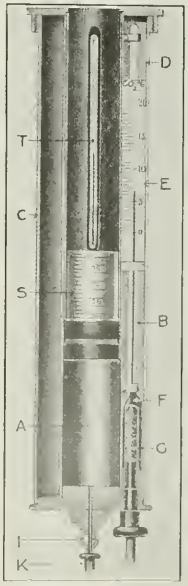


FIG. 1. THE CO_2 THERMOSCOPE

The differences of pressure cause movements of the lever *W*, which are transferred to the pen *T*, and a record of this movement is obtained upon the clockwork chart shown at *X*. The regulation of the inlet and outlet pressures of the air fan is carried out by means of a pin-valve, and by aid of this the instrument is adjusted to the zero position, when both fans are circulating air through the bells.

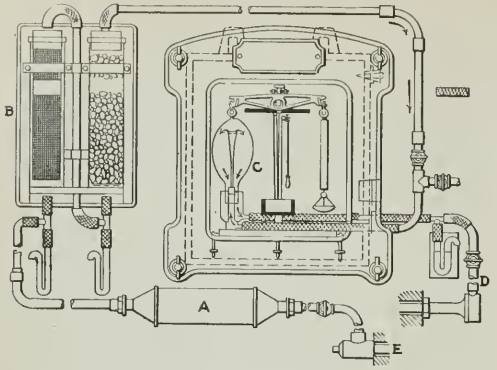


FIG. 2. ARNDT'S GAS BALANCE OR ECONOMETER

The Haber-Loewe Refractometer

The Haber-Loewe refractometer is based upon the measurement of the refractive index of the mixed gases. The method is therefore an optical one and resembles the optical methods for determining temperatures. The refractometer is illustrated in Fig. 5, and consists of the following essential parts: a prism, a telescope and a microscope. The gas to be tested is drawn through the prism, which is made of varnished metal and is provided with windows on opposite sides for the incident and reflected rays of light to enter and escape. The gas used for comparison flows through a casing. When an observation is being made with the instrument, the observer sees in the field of vision a scale, which is partly illuminated and partly in darkness. In pure air the boundary of the dark zone would coincide with zero on the scale, in air containing 0.9 per cent CO_2 this boundary would coincide with 1.0 on the scale, and the line of demarcation between the light and dark zones would be still further shifted for higher percentages of CO_2. The instrument can therefore be graduated to yield the percentage of CO_2 directly by observation, and if desired it can be provided with a photographic attachment for obtaining a permanent record, similar to that used for the Krell apparatus. The refractive indices upon which the instrument is based are the following:

Hydrogen	1.000139	Carbon monoxide	1.000340
Aqueous vapor	1.000261	Methane	1.000444
Oxygen	1.000270	Carbon dioxide	1.000452
Dry air	1.000291	Acetylene	1.000610
Nitrogen	1.000297	Ethylene	1.000678

Comparative Advantages and Disadvantages of the Various Types of Instruments

The first seven automatic gas-testing instruments described in Article II depend in each case for their action upon the absorption of the CO_2 by caustic potash, caustic soda or caustic lime and upon the measurement of the change in volume of the gas before and after this absorption.

The chief advantages of this type of recorder are that it is generally simple in construction and in its method of operation and that its running costs are low. Some of the instruments of this type are made entirely of metal and possess no glass parts or rubber connections, points in their favor which will appeal to all engineers, though not to chemists, who prefer to see

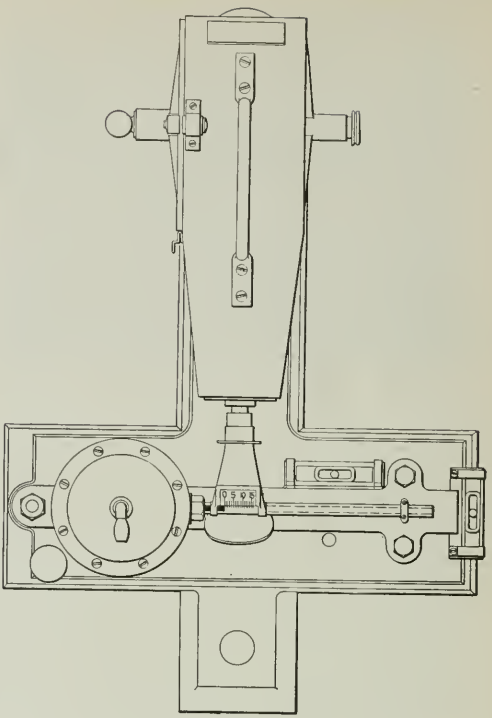


FIG. 3. PLAN OF THE KRELL CO_2 RECORDER

the inside of any apparatus they employ. For use therefore in those works where the gas-testing is in the hands of engineers the Simmance-Abady and bimeter recorders are probably the most suitable and the least likely to get out of order, while the Webster "combustion indicator" is another instrument with metal parts which has found favor with engineers in the north of England.

One of the disadvantages, however, of employing metal with caustic potash solutions is referred to on page 45 of the Report of Barkley and Flagg's investigation (Bulletin No. 91, Bureau of Mines, 1916) and it is therefore not surprising that chemists prefer the forms of apparatus of the Ados or Sarco type, in which

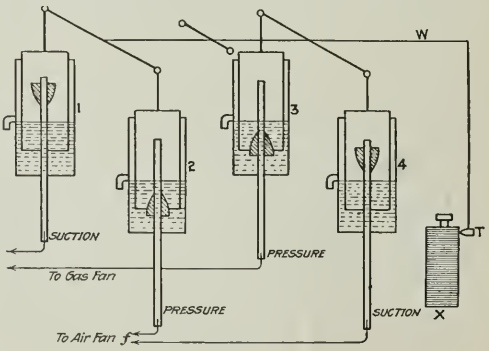


FIG. 4. THE TELEZOMETER CO_2 RECORDER

only glass and rubber are employed for construction of the principal parts of the instrument.

As regards the choice of absorbing media, the bimeter recorder, which uses caustic lime, is under present conditions much the least expensive to work, for caustic potash has increased enormously in price since the war, and it has been replaced in many instances by the cheaper but less satisfactory sodium hydrate.

The last five gas-testing instruments described in this article depend upon the measurement of some physical property of the waste gases, such as weight or refractive index, and do not require any absorbing medium for the CO_2. They are therefore cheaper to operate than the other type of instrument, for not only is the cost of caustic potash or other chemical saved, but the time taken up by recharging is dispensed with. Instruments of this type, however, call for more skill and scientific knowledge in their handling and control, and are more adapted for scientific observations and investigations than for regular use in the boiler house. It is noteworthy, and perhaps characteristic, that the more practical forms of apparatus depending upon the absorption of the CO_2 are chiefly of English and American design and manufacture, while those based upon the very exact measurement of some physical constant of the mixed gases are of German origin.

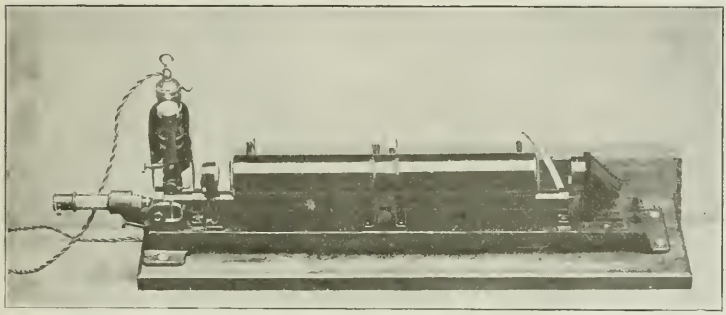


FIG. 5. THE HABER-LOEWE REFRACTOMETER FOR TESTING FLUE GASES

Checking the Results Obtained by the Automatic Recorders

The great advantage of automatic gas-testing apparatus is that it enables a constant and continuous check to be kept on the work of the stokers in place of an intermittent one, and also that it enables the chemist or chemical engineer in charge of the boilers to obtain hundreds of tests upon which to base his judgment of the efficiency with which they are being worked, in place of the few that would be possible without its aid.

As already pointed out, however, the records obtained by the automatic apparatus are not absolutely trustworthy when the boilers are being operated with a narrow margin of excess air, and at other times the CO_2 percentages recorded are too low, owing to the exhaustion of the caustic potash solution or to some other cause. The chemist or chemical engineer in charge of the boilers ought therefore to have an ordinary Orsat gas-testing set in regular use for taking and testing snap-samples of the waste gases, and when discrepancies have been found between the results of these snap-tests and the continuous records obtained by the automatic apparatus, the cause of these differences should be at once investigated and remedied. The Orsat gas-testing apparatus, in its latest form, has been illustrated and described before in these pages, and there is no need to repeat the description in this article; a few notes, however, upon its use for checking the automatic gas test results may be useful.

In the first place it is better to keep the Orsat apparatus in the laboratory and to collect the gas samples to be examined by the dry method in the usual form of gas-sample tube, holding 220 cc. and provided with glass stopcocks at each end. Fig. 6 shows a sampling tube of this type (*A*) connected to the small rubber hand pump (*C*) and valve (*B*) by aid of which snap gas samples can be collected at any point in a few minutes. About six times the volume of gas contained in the sampling tube must be aspirated through it in order to remove all the air, and by measuring the volume of water sucked in by one compression of the hand pump it is possible to calculate how many compressions are necessary to aspirate 1400 cc. of air or gas.

When the gas is very smoky, it is advisable to put a plug of glass-wool in the tube connecting the sample

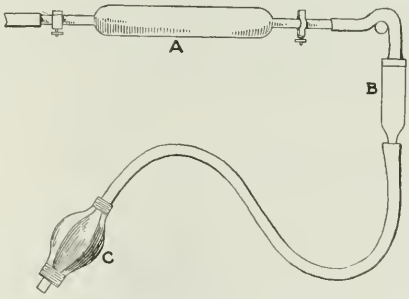


FIG. 6. GAS SAMPLING TUBE AND PUMP WITH CHECK VALVE

tube to the flue or other point whence the gas is being drawn. Half-a-dozen gas samples can be collected in this way with a minimum expenditure of time and trouble, and if the date, hour and place where taken be marked on the label of each tube, the actual testing can be deferred to any convenient time. With the stopcocks closed, the tubes are quite gas-tight and since no water or other liquid is present, beyond that which is contained as moisture in the gas, no absorption of the CO_2 or CO can occur, even if the sample be kept for hours before testing. The tubes, however, must not be placed in direct sunlight while their contents are waiting to be tested, as this may produce chemical changes in the gases.

For checking the work of CO_2 recorders the samples

must be taken from a point in the connecting tube between the filter and the automatic apparatus, as close to the latter as possible, a T piece being fixed permanently here, with a glass stopcock, for this purpose. The two tests of the automatic apparatus, the one just before and the other just after the period when the sample was withdrawn, should be noted on the label of the sample tube, together with the number of the recorder and the time and date of sampling, so that even when a large number of check tests are being carried out at one and the same time there will be no danger of confusing the results. Check tests of this kind should be carried out at regular intervals, say weekly, and also whenever a recorder seems to be working badly or is giving unexpected results as regards the percentages of CO_2.

Frequent Checks Advisable

When the boilers are being worked with a very narrow margin of excess air, in the attempt to attain high efficiencies, that is, with 12 to 14 per cent CO_2, it will be necessary to test more often with the Orsat apparatus, for if carbonic oxide gas or unburned hydrocarbon gases be allowed to escape with the waste gases, the heat losses from this cause may far exceed the heat saved by reducing the excess air.

An empirical method of judging, from the results of the CO_2 and oxygen tests, whether any unburned or imperfectly burned gases are present, is given below, but it is better, of course, to carry out the complete gas analysis and to estimate the carbon dioxide, carbon monoxide, oxygen and hydrocarbons separately in the gas mixture.

The use of the combustion method of determining the carbon monoxide and hydrocarbons is preferable to the methods depending upon absorption by cuprous chloride and fuming sulphuric acid respectively. In this case, only two absorption solutions and pipettes are required, namely, caustic potash and pyrogallic acid, and the

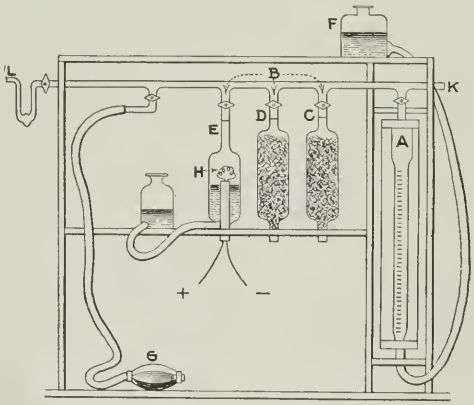


FIG. 7. IMPROVED ORSAT GAS-TESTING APPARATUS

Orsat apparatus can be reduced in bulk and size, and its operation much simplified. Details of the modified apparatus (see Fig. 7) will be found in the Handbook named below.[1]

[1] "Fuel, Water and Gas Analysis for Steam Users," by J. B. C. Kershaw, 2nd edition Constable & Co., 1918.

An Empirical Method of Determining Whether Unburned Gases Are Present in the Waste Gases From Boilers

Air contains by volume 79 per cent nitrogen and 20.8 per cent oxygen. When burning a bituminous fuel of average quality, yielding 35 per cent volatile matter when heated, about 1.8 per cent. of the oxygen

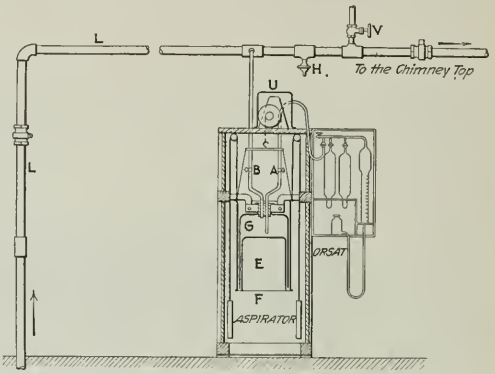


FIG. 8. SAMPLING APPARATUS FOR FLUE GASES, USED IN HAMBURG

of the air will be required to complete the combustion of the hydrogen contained in the coal; the air that remains will therefore contain only 19 per cent of free oxygen. Now any volume of oxygen yields the same volume of CO_2 on combustion, and the tests for carbon dioxide and for oxygen, when added together, ought therefore to total 19 per cent. If there be a continued deficiency in the two tests when dealt with in this manner, it indicates that carbon monoxide or hydrocarbon gases are also present in the exit gases. When burning coke or anthracite fuels, which contain only a small percentage of hydrogen and volatile hydrocarbons, this disappearance of oxygen does not occur. The CO_2 and oxygen tests of the waste gases in such cases, when added together, should equal the original oxygen contents of the air, namely 20.8 per cent.

An Automatic Sampling Apparatus for Obtaining Average Samples of the Waste Gases

When the boilers are being regularly worked with the minimum amount of excess air, it is advisable, however, to institute some more regular and systematic method of checking the presence of unburned gases than that afforded by occasional snap samples, and it is wiser to install the continuous form of sampling apparatus described below. This apparatus was introduced by the Hamburg Smoke Abatement Society some years ago, in connection with the system of boiler control worked in that town and its environs, and it is stated to have given good results, more than 400 boilers under the control of the society having been equipped with it. The apparatus is shown in diagram form in Fig. 8.

The sample of gas is drawn continuously, using natural or artificial draught, from the exit-flue by means of the pipe *L*, and as it passes over the aspirator *F* a small proportion of the gas flow is sucked down into this by the action of clockwork on the bell *E*. The aspirator above this bell is filled with water covered with a film

of paraffine oil,[2] and the rate at which the bell sinks and the gas is sucked into the space *G* above it is controlled by a pendulum and simple clockwork arrangement at *U*, the speed of which can be varied to suit the length of the firing shift. At the end of twelve or eight hours (i.e. when the firemen change) the clockwork is stopped and the average sample of gas stored in the space *G* is tested for carbon dioxide and for oxygen, by aid of the Orsat apparatus shown on the right-hand side of the aspirator, a rubber tube being employed to connect the aspirator and the Orsat apparatus. Two tests of the average samples of gas are made, and the aspirator is then emptied by raising the bell *E*, and by opening the tap *A* and the two taps shown at the entrance to the Orsat apparatus.

By closing *A*, and opening *B*, and by starting the pendulum of the clockwork again, the apparatus is set for taking the next average sample, no attention being required again for eight or twelve hours, according to the length of the working shift. The pipe *L* is kept free from soot and rust deposits by blowing steam or compressed air through it, by means of the tap at *V*, and snap samples of the exit gas can be taken when desired without stopping the aspirator, by connecting the cock at *H* with the tap at the entrance to the Orsat apparatus, by means of a thick rubber tube.

Chemical Trade Statistics

The foreign trade committee of The Chemical Alliance, Inc., is preparing a digest of the chemical export statistics of the seven chemical producing countries the combined exports of which represent 90 per cent of the world's business. Six of these require recalculations from foreign values, weights and measures into our standards. The 100 items to be listed are:

ACIDS AND HEAVY CHEMICALS

Muriatic acid
Sulphuric acid
Nitric acid
Acetic acid and acetates
Glauber's salts
Blue vitriol
Green vitriol
White vitriol
Litharge
Alum and aluminium
Sulphate
Sodium nitrate
Sulphur
Manganates and permanganates
Water glass
Sugar lead
Zinc chloride
Tin salts
Chromates
White lead
Blanc fixe
Zinc oxide
Zinc dust
Lithopone
Barium salts
Barium chloride
Barium nitrate
Barium peroxide
Chloride of zinc
Barytes
Ensom salts
Phosphates of soda
Niter cake
Sal ammoniac
Sulphides of soda and potash

COAL AND GAS BY-PRODUCTS

Gas liquor
Oxalic acid
Ammonium sulphate
Coal tar, coal tar oil and coal tar products
Coal tar pitch
Benzol (coal benzine)
Naphthalene
Anthracene
Phenol (carbolic acid phenyl alcohol)
Cresol (methyl phenol so-called 100 per cent crude carbolic acid of commerce)
Other light, coal tar oils (cumol toluol), etc., carburetted hydrogen, anthracene oil, carbolic oil, creosote oil and other heavy coal tar oils; mineral naphtha (asphalt naphtha)

ELECTROCHEMICALS

Bromine and bromides — Phosphorus — Bleaching powdel

FERTILIZERS

Phosphates of soda
Superphosphates
Natural phosphates of lime
All other fertilizers

MISCELLANEOUS CHEMICALS

Chrome alum
Ultramarine and like blues
Guncotton pyroxyline
Quinine
Glycerine, crude and refined
Cyanides
Prussian and like blue
Insecticides
Unenumerated, etc.
Iodine and iodine compounds

ALKALIES

Soda ash — Soda crystals — Soda bicarbonates — Soda caustic

DYESTUFFS AND INTERMEDIATES

Benzoic acid
Salicylic acid and salicylicates
Aniline and other coal tar dyes
Alizarine dyes
Naphthol-naphthylamine
Naphthylamine
Naphthol
Anthracine dyes and alizarine
Indigo
Acetanilid
Aniline (aniline oil)
Aniline salts
Anthraquinone, nitrobenzol, toluidine, resorcine, phthalic acid and other coal tar products

TANNING EXTRACTS

Extract of oak — Extract of chestnut — Extract of sumac
pine — gallnut — quebracho

This report requires 113,400 tabulations, of which 97,200 have to be recomputed.

[2]Recent investigations have shown that paraffine oil is not so inactive as was supposed toward gases, and brine is better for the purpose of collecting flue gas samples.

Imports and Exports

The following imports and exports for the month of December, 1918, are reported by the Special Statistical Service Section, Division of Statistics, Bureau of Foreign and Domestic Commerce, Department of Commerce:

IMPORTS OF TUNGSTEN-BEARING ORE

Countries	Tons	Value	Countries	Tons	Value
Mexico	4	$6,440	China	244	$258,720
Argentina	42	66,243	Hongkong	526	571,451
Bolivia	25	33,825	Japan	12	18,218
Chile	100	133,525			
Colombia	35	42,700	Total	1,033	$1,184,569
Peru	45	53,447			

U. S. EXPORTS OF TUNGSTEN AND FERROTUNGSTEN METAL, BY COUNTRIES

Countries	Lb.	Value
Canada	2,000	$4,400
Argentina	225	770
Total	2,225	5,170

IMPORTS AND EXPORTS OF LEAD AND ZINC, BY COUNTRIES

Articles and Countries	Gross Weight Tons	Contents, Lb.	Value
IMPORTS:			
Lead Ore:			
Canada	180	277,200	$14,553
Mexico	11,618	153,185	7,407
British South Africa	526	259,529	20,892
Total	12,324	689,914	$42,852
Lead Bullion and Base Bullion:			
Mexico	15,383,544	14,946,348	803,483
Zinc Ore and Calamine:			
Canada	1,172	932,866	19,082
Mexico	2,732	2,005,415	45,101
Total	3,904	2,938,281	64,183
FOREIGN EXPORTS:			
Lead, Pigs, Bars, and Old, total		671,227	$45,206
DOMESTIC EXPORTS:			
Lead Pigs and Bars, product of domestic ore		4,441,279	368,980
Lead Pigs and Bars, product of foreign ore		6,411,949	437,060
Zinc Spelter Cast in Pigs, product of domestic ore		13,131,377	1,368,591
Zinc Spelter Cast in Pigs, product of foreign ore		3,272,856	263,711
Zinc, Rolled in Sheets, Strips, Etc.		3,861,040	488,122

IMPORTS AND EXPORTS OF PLATINUM AND IMPORTS OF IRIDIUM ETC., BY COUNTRIES

Imports of Platinum and Iridium

Countries	Ore and Unmanufactured Platinum Oz. (Troy)	Value	Ingots, Bars, Plates, Sheets, Wire, Etc., of Platinum Oz. (Troy)	Value	Vases, Retorts, Etc., of Platinum Oz. (Troy)	Value	Iridium, Osmium, Palladium, Etc. Oz. (Troy)	Value
England			27	$2,928			1	$123
Canada	3	$315	22	2,332			134	12,486
Panama			456	38,790				
Dominican Republic			3	214				
Colombia	2,418	217,183	1,147	101,680				
Venezuela	16	1,610						
Japan	1	156	98	12,587				
Australia							35	5,769
New Zealand							4	457
Total	2,438	$219,264	1,753	$158,531			174	$18,835

Exports of Platinum

Country	Platinum Unmanufactured Oz. (Troy)	Value	Platinum Manufactured Value
Canada			$1,342

Recent Chemical and Metallurgical Patents

Making Pyroxylin Compounds.—In attempting to substitute certain non-volatile liquids for camphor in pyroxylin compounds, it has hitherto been thought necessary to remove the water from the pyroxylin before combining with the liquids. WILLIAM G. LINDSAY of Newark, N. J., has made the interesting discovery that these liquids, if mixed with wet pyroxylin, remain in the mixture when the latter is subjected to pressure between bibulous pads, while the water is entirely eliminated from the press-cake. The resultant dried cake has all the valuable properties of camphor pyroxylin compounds. Liquids mentioned as being suitable for this purpose are: benzyl benzoate, tricresylphosphate, castor oil and mixtures such as camphor, 35 parts with triphenylphosphate, 65 parts; camphor and fusel oil. (1,292,819; assigned to the Celluloid Co.; Jan. 28, 1919.)

Concentrating Nitric Acid.—Mixed nitric and sulphuric acids, such as the mixtures resulting from nitration processes, are introduced at the top of a cylindrical brick lined steel tower, having a central opening filled with pieces of quartz. Steam admitted at the bottom of the tower vaporizes the nitric acid, while the water is retained to a very large extent by the sulphuric acid. The nitric acid vapors pass to a condenser, which is so arranged that the uncondensed vapors are led off to an absorption tower in which they react with water to form dilute nitric acid. This is returned to the first tower for concentration. When applied to mixtures containing not less than 64 per cent sulphuric acid and from 3 to 25 per cent nitric acid, the process yields a product which is 90 to 97 per cent HNO_3. (1,292,948; FRED C. ZEISBERG, assignor to E. I. du Pont de Nemours & Co.; Jan. 28, 1919.)

Recovering Solvent From Colloided Nitrocellulose.—The usual method of recovering ether and alcohol used as solvents for nitrocellulose in the manufacture of smokeless powder results in a loss of a certain percentage of the solvents, in spite of the fact that about fourteen days are required to complete the four operations necessary. A process, which recovers a higher percentage of the solvents in two days, has been devised by WILLIAM F. NASH of Kenvil, N. J. The basic principle of the invention is the displacement of the ether by alcohol and the subsequent displacement of the alcohol by water. The apparatus consists of three tanks, which we will designate *A*, *B* and *C*. *A* and *B* are equipped with fractionating columns; *B* and *C* have steam coils. By means of suitable valves and connections, a single pump is able to circulate liquid either through tanks *A* and *B*, or all three in series, as desired. The nitrocellulose is placed in *A* and the ether displaced by circulating alcohol at 55 deg. C. from *B* through the guncotton, which is preferably in the form of pellets. The ether vapors pass through the fractionating column on *A* into the storage tanks. When the ether content of the pellets has been reduced to the proper value, the valve between the fractionating column on *B* and tank *B* is opened and the liquid in *B* brought to the boiling point. The connections are now arranged in such a manner that the liquid from *A* passes to *B*, where the alcohol is vaporized and conducted through the column to the storage tank, while the liquid refluxed from the column is led into *C*, where a quantity of water equal to the alcohol distilled off is added. This diluted alcohol is kept at a temperature of from 50 to 55 deg. C. and is pumped to tank *A*, thus maintaining a constant circulation of liquid, the alcohol content of which is constantly diminishing. When the material in *A* has had enough solvent extracted to give the required residual solvent when dried, the circulating liquor is all collected in *B* and the remaining solvent fractioned off. The nitrocellulose is now dried in the usual manner. (1,293,515; assigned to Hercules Powder Co.; Feb. 4, 1919.)

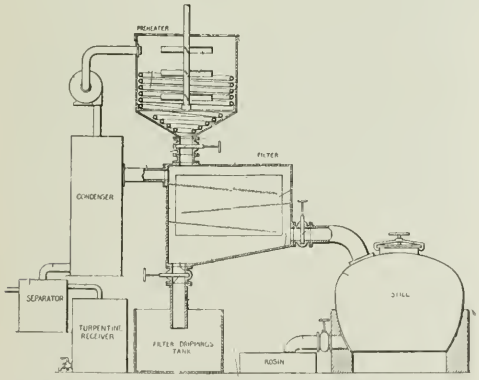
Refining Zinc Pigment.—L. E. WEMPLE of St. Louis, Mo., proposes to remove compounds deleterious to the tinctorial properties and permanency of zinc pigments made from impure raw materials. He purposely makes a first fume containing zinc sulphate, finding that objectionable lead and cadmium oxides cannot exist in conjunction with such excess. This fume is then mixed with pulverized lampblack and roasted for 30 min. in a muffle hearth at between 900 and 1200 deg. F. By a combination of reactions, the carbon reduces the excess of zinc sulphate without attacking the lead and cadmium sulphates, eliminating any arsenic and antimony compounds at the same time. At the end of the required roast, stirring is continued during a quick cooling, when excess carbon is burned out, and SO_2 and other occluded gases are largely eliminated. The method avoids coarsening of grain and recrystallization accompanying excessive heating and prevents the formation of objectionable carbonates. (1,292,976; assigned to American Zinc, Lead & Smelting Co.; Jan. 28, 1919.)

Refining Nickel-Copper Matte.—When bessemerized nickel-copper matte is ground to 60 mesh, roasted, reground, and heated with dilute H_2SO_4 at 80 deg. C., some 70 per cent of the copper is dissolved, with a little of the nickel. CARL and OTTO SANGER, of Clydach, Wales, patent a further separation as follows: The filtered residue is then mixed with 140 Tw. H_2SO_4 and heated at 150 deg. C. in cast iron pans, which converts the oxides into water-soluble sulphates. Copper in this solution is now precipitated quantitatively by finely divided metallic nickel, and the clear filtrate electrolyzed, producing copper-free nickel. (1,291,030; Jan. 14, 1919.)

Manganese Steel.—W. G. NICHOLS of Chicago proposes the following method to reuse manganese-steel scrap without great loss of manganese by oxidation or volatilization: Cold scrap, with or without additional 80 per cent ferromanganese, is charged into an electric furnace and heated carefully to about 600 deg. F., and maintained at that temperature until the non-conductive metal has a thoroughly equalized heat. Temperature is gradually raised, without the production of hot spots, until the whole is at 1200 deg. F., when a basic slag is added and a reducing atmosphere maintained so as to prevent loss in manganese. Gradually the temperature is raised to the

fusion point of the steel, and is kept without superheating until a short time before tapping. Such an alloy can be made into castings, or used as an addition to converter metal; in the latter case it is recommended that the highly heated blown metal be tapped, the slag skimmed off, the melt weighed, and a computed amount of molten manganese-iron alloy added, the latter formed as above and at a minimum pouring temperature. The resulting temperature of the mixture should then be such as to allow immediate teeming. (1,291,655 and 6; assigned to American Manganese Steel Co., Jan. 14, 1919.)

Distillation of Crude Pine-Resins.—In the manufacture of turpentine, the customary procedure of skimming the melted crude gum in the still prior to distillation is unsatisfactory. The smaller pieces of bark, chips, etc., remain in sufficient quantities to cause the discoloration of the resin during the distillation process, thereby lowering its value. The skimmings themselves are saturated with gum and contain undissolved lumps of gum. In addition to this, during the skimming process, vapors of turpentine escape from the open still, causing a further loss of valuable material. With these difficulties in mind, ROBSON DUNWODY of New Orleans has designed the improved system shown in the accompanying diagram. The crude gum is placed in the preheater and brought to a temperature not exceeding 200 deg. F., by means of the steam coils. It is then stirred vigorously to break up the lumps. Any vapors which are given off during the heating are drawn into the condenser by means of a suction fan. The gum is permitted to flow into the filter chamber, in which the coarser impurities and undissolved lumps of gum are removed



IMPROVED SYSTEM FOR DISTILLATION OF CRUDE PINE-RESINS

by a series of inclined screens of varying mesh. The sloping bottom of this chamber prevents the finer particles of sand, dirt, etc., from entering the still with the gum, which is now free from impurities and unstained, as the temperature at this stage is below that at which the impurities begin to discolor the gum. When a sufficient charge has collected in the still, the preheater valve is closed and the filter chamber drained. During the distillation, the hot vapors of turpentine pass through the filter box on their way to the condenser and melt the gum contained in the material on the screens. This gum, which contains the coloring matter extracted from the impurities, collects in the bottom of the filter chamber, is drained off from time to time and, if desired, distilled independently. The turpentine, as it issues from the condenser, is led into a separator, in which the acid water known in the trade as low wine is removed. At the end of the run, the resin is run out into a receiver and the dry skimmings left on the screens in the filter box are removed and destroyed, as the values have been completely extracted. (1,291,800; Jan. 21, 1919.)

Sintering Ores.—In down draft sintering furnaces (such as Dwight-Lloyd machines) the charge becomes more porous as the flame works downward into the cake, thus allowing an undue excess of air to cut down the roasting efficiency of the machine. The best sintering results are apparently obtained by a slow-burning process, consequently A. H. RICHARDS of Garfield, Utah, proposes to add a fresh layer of ore so timed to intercept the accelerated roasting due to excess air. This layer is then ignited on its top, and the cake then is in two layers, burning independently. The process may be repeated as often as necessary, and if properly done, will produce a continuous, evenly sintered mass, at a high tonnage rate. (1,292,059; assigned to American Smelting & Refining Co., Jan. 21, 1919.)

Roasting by Surface Combustion.—C. D. MCCOURT of London, England, patents the process of feeding a continuous stream of sized material through a suitable shaft, equipped with charging and discharging bells, and injecting into this column, through tuyeres, an explosive gaseous mixture. The speed of the blast must evidently be greater than the velocity of combustion. Temperatures considerably in excess of the ordinary result of such reactions may be had by the accelerated surface combustion. Fusing of the charge may be prevented by using a gaseous mixture of low calorific intensity, or increasing the speed with which the granular mass passes the tuyeres. Oxidizing, reducing, chloridizing or other atmospheres may be produced in this manner. (1,291,965; assigned to Surface Combustion, Inc., Jan. 21, 1919.)

Sulphidizing Roasting.—ARTHUR S. DWIGHT of New York City notes that many natural ores, for instance those of copper, are deficient in sulphur to the extent that after the volatile sulphur has been driven off in heating, not enough remains to form a matte and clean slag. By-products, such as zinc residues and burned pyrite, contain small amounts of valuable metals which could be recovered if properly sulphidized. He has discovered that if sulphur ores be pulverized and mixed with finely divided metals with a strong affinity for sulphur such as copper or iron and heated to a bright red heat, free oxygen being excluded, the unstable sulphur will unite with the metal instead of distilling. He therefore proposes to heat oxidized ores with sufficient carbon to effect the reduction of the metals, and then mix with a pulverized sulphur-bearing ore. The product becomes pasty at a comparatively low temperature, and can be delivered either in lumps for blast furnace work, or finely divided for reverberatory smelting. (1,238,279; Aug. 28, 1917.)

Personal

MR. G. C. BENSON, recently of Nobel, Ont., Canada, has accepted a position with the National Carbide Co. of Toronto as research chemist.

MR. A. S. BLAGDEN has been elected president of the Air Reduction Co., Inc., New York, N. Y.

MR. E. C. CARLYLE has resigned his position as analytical chemist with the Geo. H. Morrill Co., Norwood, Mass., and become associated with the Saarbach Laboratories, Inc., analytical and consulting chemists, New York.

MR. E. T. CASLER, formerly chemist for the Phosphate Mining Co., Nichols, Florida, is now chemist with the Air Nitrates Corp.

MR. WILLIS B. CLEMMITT has joined the engineering staff of the Powdered Coal Engineering & Equipment Co. of Chicago, Ill., in the capacity of advisory engineer. Mr. Clemmitt was formerly assistant superintendent of the open-hearth department of the Central Iron & Steel Co., Harrisburg, Pa.

MR. EDWARD S. DAVIS, chief of the Fuel Oil Section, Bureau of Oil Conservation, after six months of service, has returned to Tate, Jones & Co., Inc., Pittsburgh, Pa.

MAJOR A. C. FIELDNER, Chemical Warfare Service, U. S. A., who was in charge of the gas masks research at the American University Experiment Station, Washington, D. C., has returned to the Pittsburgh Station of the Bureau of Mines, where he will have charge of the chemical research laboratory.

DR. FEDERICO GIOLITTI, director general of the steel works of Giov. Ansaldo & Co., Italy, and of international note as a metallurgist, is now in the United States on business and is making his headquarters in New York City.

MR. C. W. JOHNSON has been appointed assistant manager of works of the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

MR. ARTHUR LACHMAN is now connected with the Great Western Electro-Chemical Co., San Francisco, Calif.

CAPTAIN P. E. LANDOLT has resigned from the Nitrate Division, Ordnance Dept., U. S. A., and has returned to his old position as chemical engineer with the Research Corporation, New York City.

MR. H. L. OLIN is now chemist in the research department of The Barrett Company, Edgewater, N. J., having been discharged from the Army at Edgewood Arsenal, where he had the rank of Captain, C. W. S.

MR. SEELY B. PATTERSON, JR., formerly assistant general manager of the Bethlehem Steel Co.'s Cuban interests, has been relieved from duty in the Engineering Corps and is now in Allentown, Pa.

MR. WALTER H. PEARCE, for three years with the Commercial Research Company, New York and Flushing, N. Y., is now metallurgist with Paul G. Niehoff & Co., Chicago, Ill.

MR. GEORGE H. RUPPERT, who, before his entry into the Chemical Warfare Service, had charge of a sodium ferrocyanide department of the Semet-Solvay Co., has accepted a position as advisory engineer with the Powdered Coal Engineering & Equipment Co., Chicago, Ill.

MR. HERBERT L. SHERMAN, formerly president of the New England Bureau of Tests, Inc., and more recently in charge of inspection for the Construction Division of the United States Army, has become a member of the firm of Arthur D. Little, Inc., Cambridge, Mass.

MR. JOSEPH T. TERRY, JR., who for some time past has been engaged in conducting flotation experiments for the American Zinc Co., Mascot, Tenn., has opened an office as a consulting engineer under the title Terry Mining and Metallurgical Corp., at Salt Lake City, Utah.

MR. TAMOTSU WATANABE of Tokyo, Japan, is visiting the industrial centers of the United States in the interests of the Mogi Commercial & Industrial Department.

Obituary

MR. HERBERT R. DRYFOOS, president of the Cleveland Alloys Co., Cleveland, Ohio, died on Feb. 18 at his home, of pneumonia.

LIEUT. ELBERT C. BAKER, the only son of J. T. Baker of the J. T. Baker Co., Phillipsburg, N. J., was killed in action Sept. 30, 1918. Lieut. Baker, a graduate of Cornell University, was engaged as a research chemist in his father's laboratory and during the one year of his employment was doing special work in standardizing methods of analysis for chemical reagents along the lines suggested by the Bureau of Standards.

Current Market Reports

The Non-Ferrous Metal Market

Saturday, March 8. — The non-ferrous metal prices are now on a peace basis with few exceptions, and an active market is expected.

Aluminium: — There is an open market for aluminium and conditions are quiet. Ingots 98-99 per cent are offered at 31c. Sheets, 18 gage and heavier, are 42c. Powder, 100 mesh, 70c.

Antimony:—Wholesale lots are offered from 7c. to 7⅛c. and jobbing at 7¼c. There is no active buying.

Copper:—During the past ten days, 25,000,000 lb. of copper was sold at from 14⅞c. to 14⅝c. per lb. The Government surplus stocks are to be turned back to the producers and a firm market is to follow from now on.

Copper sheets, hot-rolled	lb.	$0.24½—
Copper sheets, cold rolled	lb.	.25½—
Copper bottoms	lb.	.32½—
Copper rods	lb.	.21½—
Copper wire	lb.	.19½—
High brass wire and sheets	lb.	.20½—
High brass rods	lb.	.19½—
Low brass wire and sheets	lb.	.22½—
Low brass rods	lb.	.23½—
Brazed brass tubing	lb.	.31½—
Brazed bronze tubing	lb.	.36 —
Seamless copper tubing	lb.	.31 —
Seamless bronze tubing	lb.	.31 —
Seamless brass tubing	lb.	.30 —
Bronze (gold) powder	lb.	1.00 —

Lead:—The lead market has been quiet but firm and indications point to activity in the near future. E. St. Louis quotes 5c. and New York, 5½c. lb. Sheet lead, 8c. lb.

Tin:—The U. S. Steel Products Co. has liquidated over half of its 10,000-ton allotment at 72½c.

Zinc:—Spelter has taken an extraordinary decline, going from $134.50 to $121 per ton in the last fortnight. Zinc dust, 14c. Sheet zinc, 11c. lb.

OTHER METALS

Bismuth	lb.	$3 20 — $3 65
Cadmium	lb.	1 40 — ...
Cobalt	lb.	2 50 — 3 50
Magnesium	lb.	1 75 — 2 10
Mercury	75 lb.	75 00 — ...
Mercury	lb.	1 50 — ...
Nickel	lb.	40 — 45
Tungsten	lb.	Nominal
Iridium	oz.	175 00 — ...
Palladium	oz.	115 00 — ...
Platinum	oz.	97 50 —100 00
Silver	oz.	1.01⅛— ...

The Iron and Steel Market

War-time prices for steel are about to be deflated as a result of the operation of a plan devised by Secretary of Commerce Redfield and approved by the President. For this purpose the Industrial Board of the Department of Commerce has been organized, with George N. Peek, formerly vice-chairman of the War Industries Board, as chairman. At a meeting of representatives of the iron and steel industry held in New York March 6, Mr. Peek outlined the plan and it was unanimously approved. The next proceeding is the meeting between the board and a committee of the industry, to be held in the week beginning March 17. The reduced schedule of prices may be announced immediately after that meeting, but more likely further time will be required for negotiation and study of conditions.

The Government's object is to deflate prices, particularly prices of commodities involved in building operations. The operation is based on the dictum that "the law of supply and demand cannot cure what it did not create," this being a system of controlled prices for war time, set high for the purpose of stimulating production. When there is no buying, the law of supply and demand does not operate. This is a fact that the steel industry has frequently exemplified, for in periods of light demand it has refrained from reducing prices, maintaining that reduced prices would not stimulate buying.

It is recognized on all hands that the resumption of construction work depends upon the action of no one industry, and that all prices entering into construction work must come down in order to make the proposition attractive to the investor. Accordingly, while the Industrial Board begins with the iron and steel industry, it gives assurance that it will take up all building materials and some other materials as well. No program is mapped out for the distant future, and it is intimated, if not promised, that the activities will be discontinued whenever it is seen that the law of supply and demand is again operating. The proposition is welcomed by the iron and steel industry, though the industry does not advertise the fact, because it affords the opportunity that otherwise might be lacking for making a formal reduction in prices and establishing a level to which individual producers will be disposed to adhere. Without some such formality the iron and steel producers would have the opportunity of adhering to existing prices or nothing and naturally they would choose the former.

Industry Active

Up to this writing the iron and steel industry has, as a whole, experienced no hardships that would make it desirable to reduce prices radically. There has been a very remarkable situation. With practically all branches of the iron and steel market very dull, and with almost all consuming industries presenting the appearance of decided inaction, the production of steel has been very heavy. In proportion to capacity, assumed at 49,000,000 gross tons per annum, production of steel ingots in January was at 85.1 per cent, while production in February was at 83.6 per cent, this statement being predicated upon the trustworthy returns of the American Iron and Steel Industry, covering the monthly output of 29 companies which in 1917 made more than 87 per cent of the country's total output. Production at this writing is but little below the February average.

While it is marvelous that the steel industry should operate at so high a rate, with trade very dull, it is a corollary that nothing like such a rate could be continued for any length of time. In normal times more than half of all the steel produced passes into construction work and scarcely anything along this line is now being undertaken. A peculiar combination of circumstances has made it that there has been an outlet for a remarkable large quantity of steel. Ingot production in February was at the rate of about 40,900,000 gross tons a year, while in no year prior to the war was there an output as great as 31,000,000 tons, and the highest rate attained, for only a few weeks, was about 35,000,000 tons, in the early spring of 1913. At that time much steel was passing into construction work.

While the industries of the country are regarded as relatively inactive, there are some exceptions. The automobile industry is working at top speed, and while it has not yet attained the quantity production of which it is capable the necessary shop changes are nearing completion and materials and accessories are being assembled. The Ford Motor Co., for instance, which originally planned to reach an output of 3000 a day by June 1, has already attained 2500 and expects to reach 3000 by April 1. Steel shipments to the automobile industry are the heaviest on record. In nearly all the oil and gas fields there is great activity and the demand for the "oil country goods" of the pipe mills is fully up to normal. The agricultural implement factories are fairly busy, but in this case no large demand for steel is involved, as the factories had very considerable stocks. Altogether, however, it is difficult, if not impossible, to explain in full where the large steel production has been going.

Pig Iron Declines

In pig iron there has not been the same incentive for maintaining prices as has existed in the case of finished steel products. In the latter there is always a clear cut market, the price being uniformly f.o.b. Pittsburgh plus freight to destination. In pig iron the normal condition is for each district to have its own market, there being many districts, including Alabama, Virginia, eastern Pennsylvania, Buffalo, Cleveland, Chicago and "the valleys"—Mahoning and Shenango. War time control placed all furnaces, irrespective of location, on precisely the same basis, and then last September produced a still more curious alignment by putting Virginia on a Birmingham basis and eastern Pennsylvania on a Pittsburgh basis. As this alignment would certainly be departed from some time, the furnaces have had no great incentive to maintain it. The recommendation of the industry's committee last December, prepared for submission to the War Industries Board but refused consideration by the board because it was about to disband, was that a reduction of $3 be made in pig iron. This recommendation was eventually adopted by the furnaces, but since the beginning of this month there have been some recessions. A Birmingham interest, for instance, cut the recognized price of $31, Birmingham, on No. 2 foundry by $2.75 on an order for 500 tons, establishing $28.25 as the price to be shot at next. At least two eastern Pennsylvania furnaces resumed quoting on the basis of furnace, instead of f.o.b. Pittsburgh, effecting declines averaging about $2 a ton in delivered prices. Two or three valley furnaces, on quite moderate tonnages, quoted $28, furnace, or less, for No. 2 foundry, or $3 under the previously recognized market. Buffalo furnaces adhered to $31, Buffalo furnace, for local trade, but one interest circularized distant markets offering iron on a lower basis. In basic and bessemer no definite declines occurred, possibly because there was no inquiry.

Resale ferromanganese has been available at $150, f.o.b. shipping point, for 80 per cent, against makers' nominal quotations of $200, delivered, for 80 per cent and $170 for 70 per cent. The last established market was $250 for 70 per cent.

There has been only occasional and inconsequential shading of steel prices by producers. Orders have been small individually, and more likely to be placed at full prices than at concessions, for the average buyer once in receipt of a cut price quotation would be moved, not to place the order, but to seek further concessions.

The Chemical Market

Coal Tar Products:—The character of trading in coal tar products has shown little change during the interval, although there seems to have been more inquiries for the various products and producers are looking forward to a resumption of some activity. The textile industry is recovering from its recent slackness and as it is an accepted fact that this has a strong bearing on the color market, this is the best proof for the possibilities of intermediates developing a more firm position in the market. In the meantime, however, small lot transactions continue to feature the market and lower price levels have generally been effected.

Benzol:—The consuming demand for this product seems to be steady, although the various directions report stocks in sufficient quantities to take care of additional business. Producers have lowered their prices 2c. per gallon for tank car material and the reduction also applies to that in drums.

Phenol:—The weak position of the market that has been evident for some time continues and accumulations of large quantities of the product are noted in various directions. Most producers of the product have closed down their plants and some are buying back their own product at low levels to complete their unfilled contracts.

Toluol:—Resale offerings of this product seem to create some buying interest, but from all accounts second hands

seem to have little to offer. Manufacturers report a fair business passing and prices are firmly maintained.

Naphthalene:—The market for the various varieties of this product has undergone no important changes, with no disposition on the part of buyers to purchase beyond their immediate needs and even the drug trade, which is quite a factor at this season of the year, has seemingly not brought its full requirements to the market.

Alpha Naphthol:—Offerings of this product are none too liberal; however, there is no pressure on the part of buyers and no difficulty is experienced in meeting the situation. Prices are firmly maintained for both the crude and refined products.

Aniline Oil:—Another slight reduction in prices has been made by manufacturers of this commodity, who seemingly have accumulated fair quantities of stocks. While a fairly steady business is reported, individual sales noted are of a minor character.

Aniline Salt:—A steady sale is reported, but there has been no resumption of any important activities in the demand, and available stocks are more than sufficient for the current call. Prices, however, are quotably unchanged.

Alpha Naphthylamine:—Prices for this material are steady at the recent decline, but supplies are large enough to cause some concern on the part of producers, while buyers are apparently not interested in any forward stocks.

Benzidine:—There has been nothing in the way of any increase in business for this material and the recent export activity for the base product seems to have eased off, while the sulphate variety appears to be entirely neglected.

Cresol:—Trading continues along quiet lines; however, business is of sufficient volume to avoid any accumulation of stocks, with available supplies generally in proportion to the current call. Dealers have not altered their recent prices, which are firmly maintained.

Diethylaniline:—Trading in this product has been somewhat more active, which was seemingly brought about by some reductions in prices on the part of manufacturers, and transactions for the most part seem to be direct, with little trading noted through second hands.

Metanitraniline:—The market for this material is without special feature and small lot trading continues to constitute the only activity at the moment. However, there is no accumulation of stocks in any important quantity, and prices for the commodity are firmly maintained.

Metaphenylenediamine:—The continued quietness for this product has had its effect and price reductions in most directions are noted, with available supplies more than sufficient for the current call.

Diphenylamine:—Consumption requirements are in no important quantities and there seems to be a fair accumulation of stocks in the various directions, but holders have not altered their recent quotations since the recent decline; however, it is intimated on a firm order some concessions would be made.

Dinitrophenol:—There is little in the way of any important trading for this material and prices seem to be firmly maintained in most directions, although some large lot business was consummated where prices shading was effected.

Dinitrobenzol:—No material changes have developed in this market; trading is of a routine nature and individual sales are confined to small lots. Despite the quietness prevailing manufacturers are firmly maintaining prices.

HEAVY CHEMICALS:—While no important volume of trading overshadowed the market, there seems to have been more export orders about, but this activity was brought to a sudden standstill when the labor strike along the waterfronts was announced. Under these circumstances exporters were not disposed to bring their orders to the market, in view of the possibility of goods being left on docks and subject to other hazardous conditions. On the other hand, local trading continues along quiet lines, with consumers confining their purchasing to immediate needs, expecting lower price levels, but it is an accepted fact that manufacturing costs will not be much lower, especially as to wages, which proportionately reflects in the actual selling prices of many commodities. Most of the business is transacted through second hands, where competition is keen and price cutting is general when there seems to be some actual business at hand, but small lot trading constitutes the only activity in any direction. Caustic soda has attracted little attention on the part of buyers; stocks are seemingly plentiful and the market is rather weak, while the position of soda ash is more firm at the recent decline.

Soda Ash:—The consuming trade seems to be steadily taking a fair portion of supplies, which tends to keep the market rather steady for bag material. Single bags from the warehouse are now quoted at $1.55 to $1.65 by second hands. Barrels are offered at $1.85 ex-warehouse per 100 lb., although some cheap lots seem to be available at most times at $1.75. Double bags at Middle Western shipping points are held at $2.15 to $2.25, with offerings at similar prices at the Pacific Coast.

Caustic Soda:—There has been little interest noted on the part of buyers, who seem to be in a position to close in lots of ten to twenty tons at favorable prices, while round lots would be difficult to close at much less than 3c. per lb. for the 76 per cent solid, despite the fact that limited quantities are freely offered at 2⅞c. to 3c. per lb. Ground caustic seems to be gradually easing off, with offerings made at 3⅞c. to 4c. by second hands.

Cyanide of Soda:—Prices for this commodity are firmly maintained, although there is no unusual activity noted and trading seems to be confined to small lots. Purchasing is generally direct, with the 96-98 per cent material being quoted at 30c. to 31c., while the chloride mixture of 73-76 per cent is held at 25c. to 27c. and the chloride carbonate mixture is quoted at 20c. to 21c.

Chlorate of Soda:—No improvement has been noticed in the call for this product, which appears to be in liberal supply and prices are quotably unchanged ranging from 18c. to 20c.

Chlorate of Potash:—The demand is steady and trading is of sufficient volume to keep the market firm, particularly for the domestic product, which seems to be the most preferable. Prices are steady at 40c. per lb. f.a.s., while the Japanese powdered material is offered at 32c. to 33c. and the crystals at 30½c. to 31½c., according to quantity.

Yellow Prussiate of Soda:—The item continues to be neglected, with no disposition on the part of buyers to purchase forward stocks.

Bichromate of Soda:—The position of this item in the market appears to be gradually weakening, with prices fractionally declining from time to time. First hands quote from 12c. to 12¼c. for spot material with resale offerings being made at from 11½c. to 12c., and sales are reported to be passing at the inside figures in most instances.

Copper Sulphate:—There has been no resumption of any important trading in this commodity and purchasing seems to be confined to immediate needs. Standard brands of the 98-99 large crystals are now offered at 7⅞c. to 8c., while the medium crystals are held at from 7½c. to 7⅝c. for spot material.

Magnesia Calcined:—While consumption requirements seem to be of sufficient volume to keep the high-grade product well sold up, other varieties are apparently more liberal in supply. In most instances, the high-grade light variety is quoted at from 70c. to 75c. for early April delivery, and the medium grade is held at 40c. to 50c., with the heavy variety being offered at from 9c. to 10c.

Yellow Prussiate of Potash:—Small lot trading continues to feature the market and reports from the various directions indicate stocks are in liberal supply. In some instances, in the resale market, there are offerings as low as 55c., with others quoting 58c. to 60c.

Red Prussiate of Potash:—There seems to be little in the way of actual trading in this material and supplies are in sufficient quantity to take care of additional business. Prices for the material are steadily declining, with offerings now held at $1.50 to $1.60.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET MARCH 8, 1919

Acetic anhydride	lb.	.90	—	1.00
Acetone	lb.	.15½	—	.16
Acid, acetic, 28 per cent	cwt.	3.25	—	3.50
Acetic, 56 per cent	cwt.	6.50	—	6.75
Acetic, glacial, 99½ per cent, carboys	cwt.	14.00	—	14.50
Boric, crystals	lb.	.13½	—	.15
Citric, crystals	lb.	1.25	—	1.27
Hydrochloric, (22%)	cwt.	2.50	—	3.00
Hydrofluoric, 30 per cent, in barrels	lb.	.08	—	.08½
Lactic, 44 per cent	lb.	.14	—	.15
Lactic, 22 per cent	lb.	.06	—	.07
Molybdic, C. P	lb.	6.90	—	7.40
Nitric, 36 deg	lb.	.07	—	.....
Nitric, 42 deg	lb.	.08½	—	.10
Oxalic, crystals	lb.	.35	—	.36
Phosphoric, 47-50 per cent paste	lb.	.07½	—	.10
Phosphoric, ref. 50 per cent	lb.	.26	—	.30
Picric	lb.	.50	—	.75
Pyrogallic, resublimed	lb.	2.90	—	3.20
Sulphuric, 60 deg. works	ton	12 00	—	14 00
Sulphuric, 66 deg. works, tank cars	ton	19 00	—	21 00
Sulphuric, oleum (fuming), tank cars	ton	25.00	—	26.00
Tannic, U. S. P., bulk	lb.	1.40	—	1.50
Tartaric, crystals	lb.	.84½	—	.85
Tungstic, per lb. of W	lb.	1.70	—	1.75
Alcohol, sugar cane, 188 proof	gal.	4.85	—	.....
Alcohol, wood, 95 per cent	gal.	1.22	—	1.24
Alcohol, denatured, 180 proof	gal.	.40	—	.42
Alum, ammonia lump	lb.	.04½	—	.05½
Alum, chrome ammonium	lb.	.17½	—	.18
Alum, chrome potassium	lb.	.20	—	.22
Alum, chrome sodium	lb.	.12½	—	.13
Alum, potash lump	lb.	.09½	—	.10
Aluminium sulphate, technical	lb.	.02	—	.02½
Aluminium sulphate, iron free	lb.	.03	—	.03½
Ammonia aqua, 26 deg., carboys	lb.	.07	—	.08½
Ammonia, anhydrous	lb.	.30	—	.35
Ammonium carbonate	lb.	.13	—	.14
Ammonium nitrate	lb.	.16	—	.17
Ammonium sulphate, domestic	lb.	.05½	—	.05¾
Amyl acetate	gal.	3.75	—	4.25
Arsenic, white	lb.	.09½	—	.10
Arsenic, red	lb.	.35	—	.40
Barium carbonate, 99 per cent	ton	80.00	—	90.00
Barium carbonate, 97-98 per cent	ton	65.00	—	67.00
Barium chloride	ton	65.00	—	75.00
Barium sulphate (blanc fixe, dry)	lb.	.03½	—	.04
Barium nitrate	lb.	.10	—	.11
Barium peroxide, basis 70 per cent	lb.	.30	—	.32
Bleaching powder, 35 per cent chlorine	lb.	.01¾	—	.02½
Borax, crystals, sacks	lb.	.08½	—	.08¾
Brimstone, crude	ton	65.00	—	70.00
Bromine, technical	lb.	.65	—	.....
Calcium acetate, crude	lb.	.04½	—	.05
Calcium carbide	lb.	.06½	—	.08¾
Calcium chloride, 7-75 per cent, fused, lump	ton	18.00	—	22.00
Calcium peroxide	lb.	1.50	—	1.70
Calcium phosphate	lb.	.22	—	.23
Calcium sulphate, 98-99 per cent	lb.	.09	—	.09½
Carbon bisulphide	lb.	.07	—	.08
Carbon tetrachloride, drums	lb.	.14½	—	.15
Carbonyl chloride (phosgene)	lb.	.75	—	1.00
Caustic potash, 88-92 per cent	lb.	.50	—	.60
Caustic soda, 76 per cent	100 lb.	2.75	—	2.95
Chlorine, liquid	lb.	.10	—	.12
Cobalt oxide	lb.	1.60	—	1.65
Copperas	lb.	.01½	—	.02½
Copper carbonate	lb.	.31	—	.32
Copper cyanide	lb.	.65	—	.70
Copper sulphate, 99 per cent, large crystals	lb.	.07	—	.08
Cream of tartar, crystals	lb.	.55	—	.58
Epsom salt, bags, U. S. P	100 lb.	2.75	—	.....
Formaldehyde, 40 per cent	lb.	.22½	—	.23
Glauber's salt	lb.	.02	—	.02½
Glycerine, bulk, C.P	lb.	.17½	—	.18
Iodine, resublimed	lb.	4.25	—	4.30
Iron oxide	lb.	.06	—	.08
Lead acetate, white crystal	lb.	.14	—	.15
Lead arsenate (paste)	lb.	.15	—	.18
Lead nitrate, C. P	lb.	.85	—	.86
Litharge, American	lb.	.10	—	.11
Lithium carbonate	lb.	1.50	—	.....
Magnesium carbonate, technical	lb.	.16	—	.17
Nickel salt, single	lb.	.14	—	.15
Nickel salt, double	lb.	.12	—	.13
Phosgene (see carbonyl chloride)	lb.	.75	—	1.00
Phosphorus, red	lb.	.75	—	.80
Phosphorus, yellow	lb.	.50	—	.60
Potassium bichromate	lb.	.37	—	.38
Potassium bromide, granular	lb.	1.25	—	1.26
Potassium carbonate, calcined, 85-90 per cent	lb.	.21	—	.25
Potassium chlorate, crystals	lb.	.40	—	.41
Potassium cyanide, 98-99 per cent	lb.	2 50	—	2.75
Potassium iodide	lb.	3.75	—	3.80
Potassium muriate, 80-85 p. c. basis of 80 p. c.	ton	270.00	—	285.00
Potassium nitrate	lb.	.26	—	.30
Potassium permanganate, U. S. P	lb.	.95	—	1.05
Potassium prussiate, red	lb.	1.50	—	1.60
Potassium prussiate, yellow	lb.	.55	—	.58
Potassium sulphate, 90-95 p. c. basis 90 p. c.	ton	Nominal		
Rochelle salts	lb.	.46½	—	.48
Salammoniac, gray gran	lb.	.14	—	.16
Salammoniac, white gran	lb.	.13	—	.15
Sal soda	100 lb.	1.60	—	1.70
Salt cake	ton	18.00	—	20.00
Silver cyanide, based on market price of silver	oz.	.....		.....
Silver nitrate	oz.	.62½	—	.63½
Soda ash, 58 per cent, light, flat (bags)	100 lb.	1.55	—	1.60
Soda ash, 58 per cent, dense, flat	100 lb.	3.05	—	3.10
Sodium acetate	lb.	.12	—	.13
Sodium bicarbonate, domestic	lb.	.02½	—	.02¾
Sodium bicarbonate, English	lb.	.....		.....
Sodium bichromate	lb.	.12	—	.14
Sodium bisulphite, powd	lb.	.05	—	.07
Sodium chlorate	lb.	.18	—	.20
Sodium cyanide	lb.	.30	—	.31
Sodium fluoride, commercial	lb.	.14	—	.15
Sodium hyposulphite	100 lb.	3.25	—	3.75
Sodium molybdate, per lb. of Mo	lb.	2.50	—	.....
Sodium nitrate, 95 per cent	100 lb.	4.07½	—	.....
Sodium nitrite	lb.	.13	—	.14
Sodium peroxide	lb.	.25	—	.30
Sodium phosphate	lb.	.04	—	.04½
Sodium prussiate, yellow	lb.	.22	—	.24
Sodium silicate, liquid (60 deg.)	lb.	.04	—	.04½
Sodium sulphide, 30 per cent, crystals	lb.	.02½	—	.02¾
Sodium sulphide, 60 per cent, fused	lb.	.04½	—	.05
Sodium sulphite	lb.	.05½	—	.06
Strontium nitrate	lb.	.25	—	.30
Sulphur chloride, drums	lb.	.07½	—	.09
Sulphur dioxide, liquid, in cylinders	lb.	.12	—	.15
Sulphur, flowers, sublimed	100 lb.	3.05	—	3.15
Sulphur, roll	100 lb.	2.70	—	3.10
Sulphur, crude	ton	35 00	—	.....
Tin bichloride, 50 deg	lb.	.25¼	—	.26
Tin oxide	lb.	.65	—	.70
Zinc carboonate	lb.	.18	—	.20
Zinc chloride	lb.	.14	—	.14½
Zinc cyanide	lb.	Nominal		
Zinc dust, 350 mesh	lb.	.12	—	.13
Zinc oxide, American process, works	lb.	.10	—	.12
Zinc sulphate	lb.	.04¾	—	.06½

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.20	—	.25
Benzol, 90 per cent	gal.	.25	—	.....
Toluol, in tank cars	gal.	.25	—	.....
Toluol, in drums	gal.	.30	—	.35
Xylol, pure, water white	gal.	.45	—	.55
Solvent naphtha, water white	gal.	.20	—	.25
Solvent naphtha, crude, heavy	gal.	.15	—	.17
Creosote oil, 25 per cent	gal.	.45	—	.55
Dip oil, 20 per cent	gal.	.35	—	.40
Pitch, various grades	ton	8.00	—	20 00
Carbolic acid, crude, 95-97 per cent	lb.	Nominal		
Carbolic acid, crude, 50 per cent	lb.	Nominal		
Carbolic acid, crude, 25 per cent	lb.	Nominal		
Cresol, U. S. P	lb.	.18	—	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00	—	1.10
Alpha naphthol, refined	lb.	1.50	—	1.60
Alpha naphthylamine	lb.	.45	—	.48
Aniline oil, drums extra	lb.	.24	—	.25
Aniline salts	lb.	.36	—	.40
Anthracene, 80 per cent	lb.	.50	—	.55
Benzaldehyde (f.f.c.)	lb.	2.50	—	2.60
Benzidine, base	lb.	1.25	—	1.40
Benzidine, sulphate	lb.	1.15	—	1.25
Benzoic acid, U. S. P	lb.	1.45	—	1.55
Benzoate of soda, U. S. P	lb.	1.30	—	1.50
Benzyl chloride	lb.	.50	—	.....
Beta naphthol benzoate	lb.	5.50	—	6.00
Beta naphthol, sublimed	lb.	.75	—	.85
Beta naphthylamine, sublimed	lb.	2.50	—	2.55
Dichlorbenzol	lb.	.15	—	.20
Diethylaniline	lb.	2.25	—	2.75
Dinitrobenzol	lb.	.30	—	.35
Dinitrochlorbenzol	lb.	.30	—	.35
Dinitronaphthaline	lb.	.50	—	.55
Dinitrotoluol	lb.	.40	—	.50
Dinitrophenol	lb.	.38	—	.40
Dimethylaniline	lb.	.55	—	.60
Dipheoylamine	lb.	.70	—	.75
H-acid	lb.	2.35	—	2.75
Metaphenylenediamine	lb.	1.55	—	1.75
Monochlorbenzol	lb.	.15	—	.17
Naphthalene, flake	lb.	.08	—	.09
Naphthalene, balls	lb.	.10½	—	.11½
Naphthionic acid, crude	lb.	1.20	—	1.30
Naphthylamin-di-sulphonic acid	lb.	1.00	—	1.10
Nitro naphthaline	lb.	.40	—	.45
Nitro toluol	lb.	.55	—	.60
Ortho-amidophenol	lb.	6.00	—	7.00
Ortho-dichlor-benzol	lb.	.15	—	.20
Ortho-toluidine	lb.	.45	—	.50
Ortho-nitro-toluol	lb.	.65	—	.70
Para-amidophenol, base	lb.	3.25	—	3.65
Para-amidophenol, H. C. L	lb.	3.50	—	3.75
Para-dichlor-benzol	lb.	.15	—	.20
Paranitraniline	lb.	1.30	—	1.35
Para-nitro-toluol	lb.	1.50	—	1.60
Parapheoylenediamine	lb.	3.25	—	3.50
Para toluidine	lb.	1.80	—	1.85
Phthalic acid anbydride	lb.	2.50	—	3.00
Phenol, U. S. P	lb.	Nominal		
Resorcin, technical	lb.	4 50	—	5.00
Resorcin, pure	lb.	7.00	—	8.00
Salicylic acid, U. S. P	lb.	.50	—	.55
Salol	lb.	.95	—	1.00
Sulphanilic acid, crude	lb.	.25	—	.31
Toluidine	lb.	2.45	—	.....
Toluidine-mixture	lb.	.80	—	1.00

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	4.00	—	.....
Corning, Ohio	bbl.	2.85	—	.....
Somerset, Ky	bbl.	2.60	—	.....
Wooster, Ohio	bbl.	2.58	—	.....
Indiana	bbl.	2.28	—	.....
Illinois	bbl.	2.25	—	.....
Oklahoma and Kansas	bbl.	2 25	—	.....
Caddo, La., light	bbl.	2 10	—	2.25
Corsicana, Tex., light	bbl.	2.25	—	.....
California	bbl.	1 24	—	1.57
Gulf Coast	bbl.	1 25	—	.....
Mexican	bbl.	1.90	—	.....

Fuel Oil

New York	gal.	.15	—	.....
Philadelphia	gal.	.10½	—	.....
Baltimore	gal.	.07½	—	.15
Pittsburgh	gal.	.07½	—	.10½
Texas	bbl.	1.85	—	2.35
Los Angeles	bbl.	1.65	—	.....

Gasoline (Wholesale)

New York, motor	gal.	.24½	—	.....
Gas machine	gal.	.41½	—	.....
72-76 degrees	gal.	.33½	—	.39½
70-72 degrees	gal.	.32	—	.37½
67-70 degrees	gal.	.30½	—	.36½
Pittsburgh, motor	gal.	.25½	—	.....
Chicago, motor	gal.	.21	—	.....
Oklahoma, motor	gal.	.23½	—	.....
San Francisco, motor	gal.	.20½	—	.....

Paraffine Waxes

Crude, 103 to 105 deg. m.pt.	lb.	.08½	—	.09
Crude, 118 to 120 deg. m.pt	lb.	.09½	—	.10
Crude, 124 to 126 deg. m.pt	lb.	.10	—	.....
Refined, 120 deg. m.pt	lb.	.12	—	.12½
Refined, 128 deg. m.pt	lb.	.14	—	.....
Refined, 135 deg. m.pt	lb.	.16	—	.16½
Ozokerite, brown	lb.	.75	—	.80
Ozokerite, green	lb.	.85	—	.90

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.23	—	.24
Cylinder, light	gal.	.42	—	.44
Cylinder, dark	gal.	.39	—	.43
Paraffine, high viscosity	gal.	.40	—	.41
Paraffine, 0.903 sp. gr	gal.	.33	—	.34
Paraffine, 0 885 sp. gr	gal.	.26	—	.28

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f. o. b. Florida	gal.	.44	—	.....
Pine oil, steam distilled, sp. gr. 0.925-0.940	gal.	.58	—	.60
Pine oil, destructively distilled	gal.	.58	—	.60
Pine-tar oil, sp. gr. 1.02-1.035	gal.	.35	—	.....
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.42	—	.....
Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f.o.b. works	gal.	.37	—	.....
Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.28	—	.....
Pine-tar oil, ref., thin, sp. gr., 1.060-1.080	gal.	.32	—	.....
Turpentine, crude, sp.gr. 0.870-0.900	gal.	.45	—	.....
Hardwood oil, f.o.b. Michigan, ap.gr. 0.960-0.990	gal.	.23	—	.....
Hardwood oil, f.o.b. Michigan, sp.gr. 1.06-1.08	gal.	.23	—	.....
Wood creosote, rcf., f.o.b. Florida	gal.	.31	—	.....

Naval Stores

Rosin A-E barrel	280 lb.	12.20	—	12.40
Rosin F-I	280 lb.	12.45	—	12.90
Rosin K-N	280 lb.	13.50	—	14 75
Rosin WG-W	280 lb.	15.35	—	16.00
Spirits of turpentine	gal.	.69	—	.....
Wood turpentine, steam distilled	gal.	.64	—	.65
Wood turpentine, destructively distilled	gal.	.63	—	.65½
Pitch	bbl. 220 lb.	8.00	—	.....
Tar, kiln dried	280 lb.	13.00	—	13.50
Retort tar	280 lb.	14.00	—	14.50
Rosin oil, first run	gal.	.74	—	.....
Second run	gal.	.76	—	.....
Third run	gal.	.82	—	.....
Fourth run	gal.	.92	—	.....

Vegetable Oils

Castor oil	lb.	.21	—	.29
China wood oil	lb.	.20	—	.23
Cocoanut oil	lb.	.12½	—	.18
Corn oil	lb.	.13	—	.17
Cottonseed oil, crude	lb.	.17½	—	.22
Linseed oil, raw, cars	gal.	1.50	—	1.53
Palm	lb.	.18	—	.21½
Peanut oil, crude	lb.	.14½	—	.21
Soya bean oil, Manchuria	lb.	.12½	—	.15

Glues

Extra white	lb.	.31	—	.35
Cabinet	lb.	.25	—	.26
Brown foot stock	lb.	.15	—	.19
Fish glue, 50-gal. barrels	gal.	1.00	—	1.50

Miscellaneous Materials

Barytes, floated, white domestic	ton	33.00	—	36.00
Beeswax, white, pure	lb.	.63	—	.65
Beeswax, unbleached	lb.	.43	—	.48
Blanc fixe	lb.	.05½	—	.....
Casein	lb.	.17½	—	.30
Chalk, light, precipitated, English	lb.	.04½	—	.06
China clay, imported, lump	ton	20 00	—	40.00
China clay, domestic, lump	ton	15.00	—	22.50
Feldspar	ton	8.00	—	12.00
Fluorspar, gravel, f. o. b. mines	ton	28.00	—	40.00
Fluorspar, washed, powdered	ton	90.00	—	.....
Fuller's earth, powdered	100 lb.	1.50	—	2.00
Graphite Alabama	lb.	.08	—	.12
Ceylon	lb.	.09	—	.22
Madagascar	lb.	.10	—	.15
Mexican	ton	35.00	—	75.00
Japan wax	lb.	.18	—	.19
Orange shellac	lb.	.72	—	.80
Pumice stone	lb.	.04	—	.08
Soapstone	ton	15.00	—	25.00
Stearic acid	lb.	.17	—	.19½
Talc, American, white	ton	20.00	—	40.00

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	100.00	—	120 00
Chrome cement	net ton	65.00	—	.....
Clay brick, first quality fireclay	per 1000	40 00	—	50.00
Clay brick, second quality	per 1000	35 00	—	40 00
Magnesite, raw	ton	30.00	—	35.00
Magnesite, calcined, powdered	ton	50 00	—	65 00
Magnesite, dead burned	net ton	38 00	—	40 00
Magnesia brick, 9x4½x2½	net ton	90 00	—	.....
Silica brick	per 1000	45.00	—	55.00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent, carloads, f. o. b. Niagara Falls, N. Y.	ton	200.00	—	250.00
Ferrocerium	lb.	15.00	—	30.00
Ferrochromium, per lb. of Cr	lb.	.....	—	.40
Ferromanganese, domestic, 70 per cent basis	ton	150.00	—	200.00
Spiegeleisen (16-18%)	ton	57.00	—	58 00
Ferromolybdenum, per lb. of Mo	lb.	3 50	—	4 50
Ferrosilicon, 50 per cent, contract	ton	120 00	—	125.00
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	Nominal		
Ferrouranium, f.o.b. works, per lb. of U	lb.	7.50	—	.....
Ferrovanadium, f.o.b. works	lb.	.....	—	.....

Ores and Semi-finished Products

Chrome ore, 45 per cent minimum, f.o.b. Cal. per unit	ton	1.50	—	1.55
Coke	ton	6 00	—	7 00
Petroleum coke	ton	16 00	—	.....
Manganese ore, 48 per cent and over, per unit	ton	1.20	—	.....
Manganese ore, chemical	ton	80.00	—	100 00
Molybdenite, per lb. of MoS_2	lb.	.80	—	.85
Tungsten, Scheelite, per unit of WO_3	ton	Nominal		
Tungsten, Wolframite, per unit of WO_3	ton	Nominal		
Uranium oxide, 96%	lb.	3.25	—	3.60
Vanadium pentoxide, 99%	lb.	10.50	—	.....
Pyrites, foreign	unit	.17	—	.....
Pyrites, domestic	unit	.....	—	.....

Plant Supplies

BUILDING MATERIALS

Common clay bricks	M	14.00	—	15.00
Faced brick	M	37.00	—	46.00
Hollow tile, 4x12x12	M	56.00	—	86.00
Hollow tile, 12x12x12	M	162.00	—	218 00
Lime	ton	17.50	—	.....
Portland cement	bbl.	3.45	—	3.62
Single glass (82-lb.), 10x26-16x24		21.00	—	27 00
Double glass (164 lb.), 10x26-16x29		31.00	—	39.00
Yellow pine lumber	M	39.00	—	45.00
Cypress	M	70.00	—	.....
Tarred felt (14-lb. sq.)	ton	52.00	—	55.00
Roofing pitch	ton	18.00	—	22 00
Asphalt coated roofing (35-55-lb.sq.)	sq.	1.60	—	2.45
Slate surfaced asphalt shingles	sq.	5.25	—	5.50
Corrugated galvanized iron	ton	109.00	—	127.00
Putty	100 lb.	6.25	—	.....
Red oxide (Pptc. Copperas)	100 lb.	15.00	—	20.00
Native red oxide	100 lb.	3.25	—	8 00
Red metallic paint	100 lb.	1.20	—	1.50
White lead in oil	100 lb.	15.00	—	16.00
White lead (dry)	100 lb.	11 00	—	13.00
Red lead in oil	100 lb.	12.28	—	14.50
Red lead (dry)	100 lb.	14.50	—	.....
Zinc oxide (dry)	100 lb.	13.00	—	14.50
Zinc oxide—leaded	100 lb.	9.00	—	10.00
Yellow ochre	100 lb.	1.50	—	10.00
Ultra marine blue	100 lb.	14.00	—	50.00
Prussian blue	100 lb.	135.00	—	150.00
Chrome green	100 lb.	40.00	—	70.00
Paris green	100 lb.	43.00	—	49.00
Mineral black	100 lb.	1.75	—	2.25
Powdered bone black	100 lb.	5.50	—	12.00
Lampblack	100 lb.	15 00	—	45.00
Gas carbon	100 lb.	16.00	—	25.00
Mexican petroleum pitch	100 lb.	1.00	—	2.00
Gilsonite	100 lb.	2.00	—	2.50
Coal tar pitch	100 lb.	.60	—	1.25

STRUCTURAL IRON

Blue annealed sheet iron	ton	77.00	—	82.00
Black sheet iron	ton	90.00	—	96.00
Galvanized iron	ton	101.00	—	131.00
Tern plate, 8-lb. coating	ton	145.00	—	148.00
Tern plate, 15-lb. coating	ton	175.00	—	.....
Tern plate, 25-lb. coating	ton	200.00	—	.....
Tern plate, 40-lb. coating	ton	230.00	—	.....
Tin plate, prime	ton	147.00	—	155.00
Tank plates	ton	60.00	—	65.00
Beams, channels, angles, T's, Z's	ton	56.00	—	60.00
Rivets	ton	88.00	—	92.00
Steel pipe, ¾ to 3-inch	ton	51.00	—	.....
Bar iron and steel	ton	60.00	—	70.00
Chain (1 inch proof coil)	ton	150.00	—	.....
Nails, bolts, nuts, washers	ton	70.00	—	80.00
Tool steel, special alloys	ton	300.00	—	500.00
Bessemer pig iron	ton	32.00	—	35.20
Bessemer steel	ton	43.50	—	47.50
No. 2 foundry	ton	37.90	—	.....
Steel billets (4 x 4)	ton	47.50	—	.....

POWER HOUSE SUPPLIES

Steam packing, rubber duck	lb.	.99	—	1.10
Asbestos, high pressure	lb.	1.76	—	.....
Asbestos, wired	lb.	1.30	—	.....
Asbestos, graphited braid	lb.	1 21	—	.....
Asbestos, wick	lb.	.75	—	.....
Rubber, sheet	lb.	.66	—	.....
Cup grease	lb.	.07	—	.....
Transmission grease	lb.	.07	—	.....
Axle grease	lb.	.04½	—	.....
Gear grease	lb.	.04½	—	.....
Cotton waste	lb.	.08½	—	.11
Hose, underwriters, 2½ in	ft.	75	—	.....
Hose, air, ¾ in	ft.	50	—	60

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Alabama

BIRMINGHAM—The Birmingham Railway Light & Power Co., 2100 1st Ave., has awarded the contract for the installation of new gas making machinery, to the Gas Machinery Co., 1900 Euclid Ave., Cleveland, Ohio. Estimated cost, between $75,000 and $80,000. The company plans to construct an addition to its gas house. J. S. Pevear, general manager.

CHICKASAW—The Tennessee Coal, Iron & Railroad Co. plans to build two ore smelters on its property here, to take care of ore brought from Cuba by the United States Steel Corporation.

California

SAN DIEGO—Olmsted & Gillelen, engineers, 1112 Hollingsworth Bldg., have submitted report to city on sewage disposal plant. Plans include the construction of intercepting sewers to cost $320,000; small pumping station, $32,500; screening plant, $225,000, screens at 32nd St. plant, $25,000; pumps at 32nd St. plant, $4000. A. H. Wright, city clerk.

Colorado

TELLURIDE—The Tomboy Gold Mines Co., Ltd., plans to build a new flotation plant and is in the market for lumber and flotation equipment. Estimated cost, $150,000. D. A. Herron, general manager.

VANADIUM—The Primos Chemical Co. will rebuild its mill recently destroyed by fire, entailing a loss of $100,000.

Connecticut

HAMDEN (New Haven P. O.)—The town has been authorized to issue $100,000 bonds for the construction of sewers and a sewage disposal plant.

District of Columbia

WASHINGTON—The Bureau of Yards & Docks, Navy Department, has awarded the contract for the construction of a laboratory at the Naval Hospital here, to W. E. Mooney, Evans Building. Estimated cost, $16,000.

WASHINGTON—The Bureau of Yards & Docks, Navy Department, has awarded the contract for installing mechanical equipment in hygienic laboratory in the South Building to J. E. Granberry, Fendal Building. Estimated cost, $53,224.

Florida

JACKSONVILLE—The Board of Commissioners of Duval Co. will soon award the contract for furnishing approximately 1500 gallons of arsenical cattle dip, delivered f.o.b., Jacksonville, in such quantities and at such times as may be directed by the County Purchasing Agent.

ST. PETERSBURG—The city has awarded the contract for installing sanitary sewers and two 1-story Cameron septic tanks in the northeastern section of the city to the Southern Construction Co., St. Petersburg. Total estimated cost, $21,395. F. M. Nelson, city engineer.

TAMPA—The McElroy Engineering Co., Giddens Building, will soon receive bids for the construction of a sugar mill and farm, including 20 miles tramway. Estimated cost, $800,000. Owner's name withheld.

Georgia

SAVANNAH—The Reliance Fertilizer Co., 106 Bay St., plans to build a fertilizer plant. Estimated cost, $100,000. Lockwood Greene & Co., Healey Building, Atlanta, engineer.

Illinois

CHICAGO—The Armour Soap Works, 31st and Benson Sts., plans to build an addition to its distilling plant. Estimated cost, $35,000. R. C. Clark, architect, care owners, is receiving bids.

CHICAGO—The Municipal Tuberculosis Sanitarium, Crawford and Bryn Mawr Ave., will soon award the contract for the construction of a 2-story, 57 x 123.8 ft. laboratory and connecting tunnel, including sterilizing, serum and operating rooms, etc. Total estimated cost, $75,000. J. Hunt, 30 North Michigan Ave., architect.

EAST ST. LOUIS—The Obear Nestor Glass Co., Broadway and Terminal R.R., has awarded the contract for rebuilding part of its factory destroyed by fire, to Ferdinand Ganschinietz, 501 North 18th St. Estimated cost, $65,000.

LINCOLN—The Illinois China Co. will build a 5-kiln pottery plant, and install kilns and drying shed. A. Smith, manager.

WOODRIVER—The Board of Education will install equipment for the chemical and physical laboratory in the 2-story, 90 x 150 ft. high school which it plans to build. Total estimated cost, $90,000. J. W. Kennedy, Cahokia Bldg., East St. Louis, Engr.

Indiana

FT. WAYNE—The city plans to build a dam, filtering and purifying plant, having a capacity of 12,000,000 gals. Estimated cost, $500,000. H. W. Becker, clerk of the board of public works. C. H. Hurd, 807 Merchants Bank Building, Indianapolis, engineer.

HAMMOND—The city plans to build a water filtration plant. W. Bridge, city engineer.

Iowa

HURON—The Board of Education will receive bids until March 20 for the construction of a 2-story, 60 x 72 ft. high school building, including laboratories, auditorium, etc. Estimated cost, $50,000. N. Schrock, Oakville, president. H. C. Eckland & Co., McKinnie Building, Moline, Ill., architect.

Maryland

BALTIMORE—The City Water Department plans to build a new filtration plant, having a capacity of 120,000,000 gals. per day, as an addition to the existing filtration plant at Lake Montebello, which has a capacity of 128,000,000 gals. per day; also construct experimental filters for comparing the efficiency of mixing coagulants at the Montebello filters. W. E. Lee, City Water Engr.

CURTIS BAY (Baltimore P. O.)—The Mexican Petroleum Co., 120 Broadway, New York City, N. Y., plans to build a large refinery here. Estimated cost, $1,000,000.

Missouri

ST. LOUIS—The J. C. Finck Mineral & Milling Co., 101 Barton St., will build a 2-story, 78 x 105 ft. addition to its barytes milling plant. Estimated cost, $8,000. C. P. Delore, engineer.

ST. LOUIS—Gerst Bros. Meat Co., 3823 Lucky St., has awarded the contract for the construction of a lard rendering and cooling plant to Gillespie & Daly Co., International Life Building. Estimated cost, $20,000.

ST. LOUIS—The Monsanto Chemical Co., 2nd and Lafayette Sts., will build a 1-story, 62 x 176 ft. factory at 102 Lafayette St. Estimated cost, $20,000. L. Veillon, 2nd and Lafayette Sts., engineer.

Nebraska

LINCOLN—The city plans an election April 8 to vote on a $100,000 bond issue for the construction of 4½ miles of collecting and intercepting sewers and sewage disposal plant. A. Dobson, 945 D St., engineer.

Michigan

THREE RIVERS—The Eddy Paper Co., White Pigeon, plans to build a new plant here. Estimated cost, $1,750,000.

New Jersey

MILLTOWN—The Elizabethtown Water Co., 68 Broad St., Elizabeth, plans to build a pumping station and filter house near here. M. Sherrerd, engineer.

NEW BRUNSWICK—The Eastern Potash Co., 120 Broadway, New York City, N. Y., will build a potash plant here consisting of ten buildings. Estimated cost, $2,000,000.

New York

BATH—The County Dairymen's League will install laboratory equipment and an ammonia system in the dairy plant which it plans to build here. Total estimated cost, $150,000. M. W. Davison, director.

NEW YORK—Frank Dowling, borough president, has awarded the contract for furnishing and delivering 40,000 gals. of gasoline to the Tidewater Oil Co., 11 Broadway. Estimated cost, $9800.

BROOKLYN—The State Hospital Commission, Capitol, Albany, received bids Feb. 19 for building a sewerage disposal plant at the Brooklyn State Hospital, here, from Murphy Bros., 262 Bay 43rd St., Brooklyn, $22,483 (200 days). L. F. Kelly, Inc., 296 Stuyvesant Ave., Brooklyn, $22,540 (200 days); J. L. Sigretto & Co., 455 Woodhaven Ave., Woodhaven, $23,000 (200 days). Noted Feb. 15. The contract was awarded to Murphy Bros.

CHITTENANGO—The Building Commission of the Dairymen's League will install laboratory equipment in the modern milk handling plant which it plans to build. Estimated cost, $20,000.

CORTLAND — The Dairymen's Local League will install laboratory equipment in the modern milk plant which it plans to build here. Estimated cost, $50,000. W. F. Webb, president.

ROCHESTER—The Dairymen's League plans to install laboratory equipment in the milk handling plant which it plans to build for the city. Total estimated cost, $150,000. G. M. Tyler, president.

TUCKAHOE—The Hodgeman Rubber Co. plans to build a 1-story, 50 x 150 ft. factory. W. L. Stoddard, 9 East 40 St., New York City, architect.

UTICA—The State Hospital Commission, Capitol, Albany, received bids March 4 for the construction of a 2-story, 44 x 60 ft. laboratory and mortuary at the State Hospital here, from La Porte & Goodman, Albany, $23,900; J. Gleason, Ilion, $26,970; Kimberly Construction Co., Mayro Building, $28,573. Noted Feb. 15.

WILLARD—The New York State Hospital Commission plans to build a chlorinating plant at the Willard State Hospital here. F. L. Warne, steward; L. F. Pilcher, Capitol, state architect.

North Carolina

WILMINGTON—Morris & Co., 38 South Dearborn St., Chicago, Ill., plans to build a fertilizer factory on a site recently purchased here.

Ohio

CLEVELAND—The Reflex Ignition Co., 1708 Payne Ave., has increased its capital stock from $100,000 to $250,000 and plans to build an 80 x 160 ft. plant.

SILVER LAKE (Bellefontaine P. O.)—The village plans an election soon to vote on a $26,000 bond issue for the construction of a sewage disposal plant. E. A. Tewksbury, clerk.

SPRINGFIELD—The city plans to build a sewage disposal plant.

Oklahoma

DUNCAN—The city will soon receive bids for the installation of new machinery for the sewage disposal plant. Estimated cost, $10,000. Benham Engineering Co., Colcord Building, Oklahoma City, engineer.

OKLAHOMA CITY—The Magnolia Petroleum Co., 212 Oklahoman Building, will soon award the contract for the construction of a 1-story gasoline refinery. L. H. Bailey, 1214 North Oklahoma St., architect.

Oregon

MOLALLA—The Molalla Fire Clay Co. plans to build a 1-kiln pottery factory on a 32-acre site, northwest of here, recently donated by the city. B. S. Sinoheimer, secretary.

Pennsylvania

CLARENDON—The Tiona Refining Co. plans to rebuild its plant here recently destroyed by fire.

HUNTINGDON—The borough has retained Gannett, Seely & Fleming, Engr., 204 Locust St., Harrisburg, to make a detailed study, report and plans for complete

rehabilitation and purification of the borough water supply. A filter plant will probably be built.

MANHEIM—The U. S. Asbestos Co. plans to build a 1-story, 60 x 100 ft. and 50 x 200 ft. addition to its plant, to provide for increased capacity

PHILADELPHIA—The Babies Hospital of Philadelphia, 1126 Walnut St., will install a chemical laboratory in the 7-story, 41 x 91 ft. hospital which it plans to build on 7th and Delancey Sts. Total estimated cost, $80,000. C. A. Ziegler, Bailey Bldg., architect.

PHILADELPHIA—Powers, Weightman & Rosengarten, 916 Parrish St., have awarded the contract for the construction of a 4-story, 28 x 40 ft. factory for the manufacture of chemicals, to R. C. Ballinger & Co., 218 North 13th St. Estimated cost, $30,000.

TEMPLE—The Temple Malleable Iron & Steel Co. has awarded the contract for the construction of a 1-story, 340 x 380 ft. plant near the Schuykill Division of the Penusylvania R.R., to F. D. Chase, People's Gas Building, Chicago, Ill. Plans include the installation of a chemical laboratory to use electro-metallurgical process. Total estimated cost, $350,000.

WILKES-BARRE—S. T. Romberger Co., Franklin Junction, plans to build a 2-story, 24 x 30 ft. rendering plant. Estimated cost, $10,000. C. Wannenwesch & Co., 563 Williams St., Buffalo, N. Y., architect.

South Dakota

HILL CITY—The American Tin Mining Co. is in the market for a Telsmith gyratory crusher, a Hardinge conical ball mill, three Richards pulsator classifiers, one settling cone, an electric furnace, two oil storage tanks and other equipment. Estimated cost, $21,000.

Texas

WACO—The Riverside Oil & Refinery Co., Oklahoma City, Okla., plans to build an oil refinery having a daily capacity of 1500 bbl.

RANGER—The city plans to build a distilled water plant. Estimated cost, $10,000. W. M. Powell, manager.

Virginia

NORFOLK—R. T. Lipscombe, 34 Virginia National Bank Building, and others plan to build a dehydration, ice and cold storage plant. Estimated cost, $225,000. B. Mitchell, Seaboard Bank Building, architect.

West Virginia

CLARKSBURG—The Clarksburg Water Board has awarded the contract for the construction of an addition to the mechanical filtration plant to the American Water Softener Co., 1011 Chestnut St., Philadelphia, Penn. Noted Mar. 4.

MARTINSBURG—The city plans to build sewerage system to include a sewage disposal plant. T. W. Sparrow, city engineer.

British Columbia

VANCOUVER—The Tudhope Electric Metals, Ltd., has awarded the contract for the construction of a smelting plant to M. P. Cotton, 1537 Matthews St.

Saskatchewan

REGINA—The City Council plans to install a filtration and softening plant for the city's water supply.

Ontario

CONISTON—The Mond Nickel Co. will make improvements to its plant and install additional machinery. C. V. Corliss, manager.

NORWAY—The city plans to build a sewage disposal plant. Estimated cost, $45,000. J. Brown, engineer.

WELLAND—The Maple Leaf Milling Co., Ltd., will rebuild its mill recently destroyed by fire. R. Cooper, manager.

Quebec

EAST ANGUS—The Brompton Pulp & Paper Co. plans to build an addition to its plant. Estimated cost, $60,000. D. L. Spence, 246 Beaver Hall, Montreal, architect.

VERDUN—The city is having plans prepared by A. E. Cohy Sons, engineers, City Hall, for improving and enlarging the waterworks and filtration plants. Estimated cost, $200,000.

Coming Meetings and Events

THE AMERICAN CHEMICAL SOCIETY will hold a meeting in Buffalo, April 7 to 11.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its annual meeting in New York City from April 3 to 5.

THE INTERNATIONAL MINING CONVENTION will be held in Vancouver, B. C., Canada, March 17-19.

THE NATIONAL FOREIGN TRADE COUNCIL will hold its sixth National Foreign Trade Council at the Congress Hotel, Chicago, Ill., on Thursday, Friday and Saturday, April 24, 25 and 26, 1919.

THE SOCIETY OF INDUSTRIAL ENGINEERS plans a national conference at New York March 18-21 at the Hotel McAlpin, at which there will be a discussion of labor by both employers and labor leaders. Internal plant organization and also the elimination of fatigue will be other leading topics.

Manufacturers' Catalogs

DE LAVAL STEAM TURBINE CO., Trenton, N. J., has issued a 32-page catalog describing standardized geared turbine units for marine service. The gain in fuel economy of the steam turbine over the reciprocating engine is stated to be approximately 25 per cent. The geared turbine weighs about half as much and occupies less than a third of the cubical space required by the engine. It is also more accessible and easier to repair, the expense for supplies and attendance is considerably less. The new publication describes the details of construction of turbines and gears and also various turbine-driven auxiliaries, including lighting sets, circulating pumps, boiler feeders, etc. A new development is the centrifugal pump for the continuous purification of the oil used in the turbine and gear bearings and on the gear teeth.

THE CRESCENT BELT FASTENER CO., 381 Fourth Ave., New York, wants all interested companies to take advantage of the bulletin and service chart entitled "Why People Buy Crescent Belt Fasteners," which may be obtained upon request.

THE WALTER A. ZELNICKER SUPPLY CO., St. Louis, Mo., has just issued Catalog No. 259, on new and used tanks.

THE LAKEWOOD ENGINEERING CO., Cleveland, Ohio, calls attention to Bull. No. 25, which shows the Lakewood line of storage battery tractors and trucks for all kinds of industrial haulage. On page 14 is an unusual table giving the type of trailers recommended for different classes of work, which is based on actual tests. Another interesting feature is the standardization of a few types of trailers instead of making a great number of different designs, which results in the higher development of each standard trailer.

WILSON WELDER & METALS CO., INC., New York, has just received from the press a catalog entitled "Repair of the German Ships," which was the biggest welding repair job in the history of the world. Many interesting illustrations are given showing cylinders before and after welding.

THE BROWN HOISTING MACHINERY CO., Cleveland, Ohio: Catalog K 1919 illustrates and describes in 96 pages Brownhoist locomotive cranes. This attractive catalog deals with buckets, capacities of cranes, clearances of cranes, coal and coke handling, construction work, 3-5 and 30-40 ton cranes, dock, dragline, electric, excavating, foreign and gasoline-driven cranes, lumber handling, magnet work, orange-peel, ore handling, pile drivers, portal-pier, sand handling, shipbuilding, special cranes, stone handling, wharf cranes and work-car cranes.

THE EASTMAN KODAK CO., Rochester, N. Y., has just issued a price list of Eastman organic chemicals.

THE CHAS. A. SCHIEREN CO., New York City, has recently received from the press a price list which differentiates the various brands of Schieren beltings not only by name and marking but also by grades and weights. This is a valuable feature to the buyer, as it enables him to select by name a Schieren belting which will meet his specifications, and he will know exactly what to expect when ordering by name. It also obviates, to a great extent, chances of the buyer selecting a belting largely upon a price basis, as the specifications show what can be expected of the various brands, in actual service. In other words, while the detail specifications enable the buyer to select a brand of belting best suited for his service, these same specifications also tend to keep him from selecting a brand which would not do his work satisfactorily. This company has also issued an attractive catalog entitled "The Story of Schieren Beltings," which is really a textbook on the leather belting business, and is handy for a reference book. The business of tanning hides and manufacturing the leather into belting is treated in a thorough manner, step by step, and many illustrations are given, in colors.

THE CUTLER-HAMMER MFG. CO., Milwaukee, Wis., is distributing the 1919 edition on wiring device written in Spanish, which has 24 pages. It lists and illustrates the majority of the C-H wiring devices shown in the 1919 English catalog. We have also received the catalog on C-H Wiring Devices,' Push Button Specialties (written in English), which gives in 64 pages a description and a list of push sockets, switches, a table listing conduit fittings made by eleven manufacturers, interchangeable plugs and receptacles, automobile lighting switches and control switches.

Stocks and Bonds

Closing Bid and Asked Quotations Mar. 12, on N. Y. Stock Exchange

CHEMICAL COMPANIES

	Bid	Ask		Bid	Ask
Am. Ag. Ch...	105½	106	Mat. Al, Wk..	28	44
do. pf.....	100	102	Ten. C. & C.	12½	12½
Barrett Co...	122	123	Un. Dyewood	55	61
do. pf.....	113	115	do. pf ...	90	95
Gen. Chem...	170	185	Va.-Car. Ch..	57½	58
do. pf.....	103	106	do. pf.....	111½	112½
Int. Ag. Ch..	15	16¼			
do. pf.....	60	60½			

Bonds

Am. Ag. Ch., 1st cv. 5s, '28.....	97	99½
Am. Ag. Ch., cv. db. 5s, '24.....	104	106
Int. Ag. Ch., 1 mtg. & col. tr. 5s, '32.....	80	80½
Va.-Car. Ch., 1 mtg. 5s, '23.....	95½	96
Va.-Car. Ch., cv. db. 6s, '24.....	101	101½

PETROLEUM COMPANIES

	Bid	Ask		Bid	Ask
Asso. Oil Co..	74	74½	P-A Pet & Tr	82½	82¾
Cal. Pet.....	27⅜	27⅝	do. pf.....	144	145
do. pf.....	74½	74¾	Pierce Oil....	17⅛	18
Col. G. & E..	45⅛	46	Royal Dutch.	95	95⅛
Mex. Pet.....	186½	187	Sinclair O & R	36⅝	36¾
do. pf.....	106	110	Texas Co....	207	207½
Ohio Cit. Gas.	38¼	38½	Tex. Pac. Ld.		
do. pf.....			Tr.....	245	285
Ohio Fuel S..	45⅛	46	Tidewater Oil.	221	223
Okls. P. & R..	8⅛	8½			

Bonds

Columbia Gas & Electric, 1 5s, '27.....	80	85
Col. G. & El., std. 1 5s, '27.....	81	84
Pan-Am. Pet. & Tr. 1 6s, '19-'27.....	130	....
Pierce Oil, cv. db. 6s, '24.....	92½	92⅞
Pierce Oil, cv. 5% Notes, '20.....	100⅛	101
Sin. O.& R. 1 ln. 7s, '20, with stk. war.....	94½	100
Sin. O.& R. 1 ln. 7s, '20 without stk. war..	96⅛	96½
Texas Co., db. 6s, '31.....	102⅛	103
Union Oil of Cal. 1 5s, '31.....	93	94
United Fuel Gas 1 mtg. 6s, ser. A, '36....	95	96

IRON AND STEEL SECURITIES

	Bid	Ask		Bid	Ask
Am. St. F....	86	86½	Pitts. Stl. pf.	90	98
Beth. Steel..	66½	67	Rep. Iron &		
do. class B.	66½	67	Steel.....	82½	83
do. pf., 8%.	104½	104½	do. pf.....	102½	104
do. pf., 7%.	90½	98	Sloss Sheff. I.		
Central Fdry.	17	21	& S.....	56½	57
do. pf.....	34	36	do. pf.....	86	90
Col. F. & I...	41½	41½	Superior Steel	36	38½
do. pf.....	108	125	do. 1 pf....	92	102
Cruc. Steel...	67½	67½	Trans. & W.		
do. pf.....	94½	100	Steel.....	38½	39½
Great No. Ore	43½	44	Un. Alloy St..	41½	41¾
Gulf Sta. Steel	57	59	U.S.C.I.P.&F.	19	20
do. 1 pf....	96	98	do. pf.....	52	53½
Lack. Steel...	70½	70½	U. S. Steel...	96½	96⅝
Mid. St. & Ord	46½	46½	do. pf.....	114½	115
Nova Scotia			Va. Coal, I&C	58	60
Steel.....	49	51			

Bonds

Beth. Steel, 1 ext. gtd. S.F. 5s, '26.....	96	96½
Beth. Steel, 1 ln. ref. 5s, Ser. A, '42.....	89	89½
Beth. Steel, P. M. & I. S. F. 5s, '36.....	82½	83
Buff. & Susq. Iron, 1 S. F. 5s, '32.....	91	96
Buff. & Susq. Iron, deb. 5s, '27.....	....	....
Cent. Found. 1 mtg. S. F. 6s, '21.....	....	....
Col. F. & I., gn. S. F. 5s, '43.....	89	90
Ill. Steel, db. 4½s, '40.....	83	84½
Ind. Steel, 1 mtg. gtd. 5s, '52.....	97	98
Lack. Steel, 1 5s, '23	96⅞	97½
Lack. Stl., 1 con. mtg. cv. 5s, Ser. A, '50.	87	89
Mid. St. & Ord., clt. cv. S. F. 5s, '36.....	86½	86⅞
Nat. Tube, 1 mtg. gtd. 5s, '52.....	....	....
Rep. I. & S., S. F. mtg. 5s, '40.....	95½	96½
Tenn. C. & I. R.R., gn. 5s, '51.....	92	95
U. S. Steel, S. F. 5s, '63.....	100	100½
Va. C., I. & C., 1 5s, '49.....	87½	89½

Published SEMI-MONTHLY *on the* FIRST *and* FIFTEENTH *of each month*

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

McGRAW-HILL COMPANY, INC.
Tenth Avenue at 36th Street
NEW YORK

JAMES H. McGRAW, President
ARTHUR J. BALDWIN, Vice President E. J. MEHREN, Vice President
J. MALCOLM MUIR, Vice President EDWARD CALDWELL, Treasurer
JAMES H. McGRAW, JR., Secretary

TELEPHONE, 2840 Greeley CABLE ADDRESS, Machinist, New York

WASHINGTON, Colorado Bldg. SALT LAKE CITY, Newhouse Bldg.
CHICAGO, Old Colony Bldg. PHILADELPHIA, Real Estate Trust Bldg.
SAN FRANCISCO, Rialto Bldg. CLEVELAND, Leader-News Bldg.
LONDON, 6 Bouverie St., E. C. 4.

H. C. PARMELEE, Editor
ELLWOOD HENDRICK, Consulting Editor
ERNEST E. THUM, Western Editor
WALLACE SAVAGE, Assistant Editor

Yearly Subscription price for United States, Mexico and United States dependencies, $3; all other countries, $4. Single Copy, 25c.
When change of address is ordered, the NEW and the OLD addresses must be given. Notice must be received at least 10 days before change takes place. No back copies for more than three months.

Copyright, McGraw-Hill Co., Inc., 1919. Entered as second-class matter July 13, 1918, at the Post Office at New York, N. Y., under the Act of Congress of March 3, 1879.

Circulation of this issue 12,800 *copies*

CONTENTS *for April* 1, 1919

Volume, XX, *Number* 7

EDITORIAL

Warning! Beware the Gas-Mask!..... 305
Nitro-Aromatics vs. Nitroglycerine..... 306
Research Forbidden to Railway Companies..... 306
An Appraisal of the American Potash Industry..... 306
Commodity Values and Construction Work..... 307

READERS' VIEWS AND COMMENTS

Potash Recovery. By *N. H. Gellert*..... 308
An Example of Crystal Crushing. By *George F. Comstock* 309
Future of the Potash Industry. By *J. W. Turrentine*..... 310
Application of Nitro-Aromatic Compounds in Explosives Industry. By *J. R. Mardick*..... 311
High Stacks for Smoke Dissipation. By *Stuart Croasdale* 311
A Great Opportunity for Intelligent Location of Industries. By *William Miller Booth*..... 313
Report of Alien Property Custodian on the Metal Industry... 313
Supreme Court Hears Minerals Separation vs. Butte and Superior..... 318
New General Import License..... 319
Manganese and Chromium in California..... 319
Waste Paper-Mill Bark as a Source of Tannin..... 319
Exhibit on Method of Classification of Personnel..... 319
Opportunities for Disabled Men..... 319
Surplus Acid in the War Department..... 319
Expansion of Japan's Trade During the War..... 319
The United States Ammonium Plant, Perryville, Md..... 320
Reclaiming Steel Works and Industrial Wastes. By *Francis Hall*..... 326
Commission to Settle Losses on War Minerals..... 327
Practical Considerations in Ammonia Leaching of Copper-Bearing Ores. By *Lawrence Eddy*..... 328
Semi-Annual Meeting of the American Institute of Chemical Engineers..... 334
New Jersey Chemical Society..... 334
Imports and Exports..... 334
Future of Industrial Organic Chemistry. By *Harold Hibbert*.. 336
Good Flotation Oils From Crude Tar Products..... 341
Zinc for Rail Bonding..... 341
Notes on So-Called "Flakes" in Steel. By *Haakon Styri*.... 342
Melting Points of Chemical Elements, and Other Standard Temperatures..... 351
Solid Rubber Tires. By *Andrew H. King*..... 352
Cleaning Furnace Gases Without the Use of Water. By *J. C. Barrett*..... 359
Book Reviews..... 361
Personal..... 361
Current Market Reports—Non-Ferrous Metal Market, Iron and Steel Market, Chemical Market and Chemical Price List..... 362
Industrial News, Coming Meetings and Events, Stocks and Bonds, Industrial Notes and Manufacturers' Catalogs.... 366

Warning! Beware the Gas-Mask!

A WORD of caution—perhaps it should be repeated many times and in many places—is in order regarding the indiscriminate use of the Army gas-mask. These can readily be had, either from returning soldiers or from dealers—as apparently there is little to prevent a manufacturer from producing a replica for sale. Men from the other side have implicit confidence in them—this was drilled into them in the back areas and later became strengthened from their own observation in the fighting line; without a mask, a man was a casualty; with a mask, all manner of "hell pepper" couldn't touch him.

Naturally these men will now not hesitate to don a mask and rush into almost any smoke or fume filled room, sure of that adequate protection which is utterly lacking in many instances. The confidence so carefully built up in the Army must be dispelled in civil life, and anyone who cherishes a gas-mask against a time of emergency should be carefully warned as to its limitations.

It is not widely realized that the nervous system cannot detect a deficiency of oxygen. The remarkable sensibility to "close" or "stuffy" atmosphere is a reaction against excess carbon dioxide rather than against lack of oxygen. Thus a normal person gradually deprived of oxygen, either in a test chamber or by ascending to extremely high altitudes, does not realize that he is being gradually stifled by lack of that necessary element and he suddenly loses consciousness without any preliminary warnings.

Herein lies the danger of indiscriminate use of the Army gas-mask. It is a gas-filter, pure and simple, designed to remove from the air the generally minute percentages of excessively poisonous gases which characterize the modern battle area. But carefully note that nowhere, except in the immediate proximity of a shell-burst, is the amount of toxic gas sufficient in amount materially to reduce the actual amount of oxygen passing through the breathing apparatus and entering a man's lungs.

A little consideration immediately indicates how different are conditions in a burning structure, a smoke flue, or a gas-filled room. Here a large proportion of the oxygen has already been consumed and replaced by such gases as carbon monoxide, carbon dioxide, sulphur dioxide, methane or ammonia. Even though the canister-filling would remove such gases (which in general it will not), the amount of oxygen contained in a lungful of the resulting atmosphere is quite insufficient to maintain life, and the result is the speedy collapse of the unwary victim. To live in such places a man must evidently wear a mask or helmet of a radically different type, that is to say, one which generates oxygen within itself.

The foregoing should not be interpreted as meaning that the tremendous amount of labor and thought expended on our Army gas-masks will be lost to industry. Quite the contrary. There is no reason why proper absorbents cannot be used effectively to clear the many dangerous fumes and smokes occurring in work-a-day life—different absorbents evidently will be used for the wide variety of gases encountered. But take especial pains to emphasize to miners, firemen, chemical workers and smelter men that the good old gas-mask which took them safely through the Argonne is powerless to aid them against fire-damp, in burning buildings, gas chambers or furnace flues. It's not the fault of the mask—it can be loaded so as to filter out almost anything, but it cannot supply a lack of oxygen which a man does not miss until it is too late!

Nitro-Aromatics vs. Nitroglycerine

WHEN the armistice was declared the War Department had 50 million pounds of TNT in its possession. The Government had built and equipped numerous plants for the recovery and nitration of toluol and the manufacture of picric acid, and in general there had been a great expansion in the production of nitro-aromatics. For want of more intelligent disposal somebody proposed to dump the TNT into the sea; and with the end of the war vast and expensive plants were promptly closed. What is the prospect for reasonable salvage?

Here is a situation, the future of which should appeal to industrial chemists of vision—the application of nitro-aromatics in the explosives industry, adapting a war munition to purposes of peace. The economics of the matter, as a correspondent points out elsewhere in this issue, favor the development of nitro-aromatics as against continued reliance on nitroglycerine. The proposal will encounter prejudice and inertia, but we doubt if even the prejudiced would contend vigorously that "it can't be done." If private initiative is lacking, the subject would be suitable for investigation by a Government agency.

Research Forbidden to Railway Companies

WE shall not undertake to discuss the merits of the Government administration of railroads from the standpoint of transportation or investment. Every free-born American citizen is supposed to hold that he knows how to run a newspaper or a railroad; and whether he can or not, he is entitled to his own opinion as to the management and the service rendered. The former director-general of railway administration, the HON. WILLIAM G. MCADOO, invited everybody to write him freely, and say what he thought about his work and the manner in which he did it; and if this invitation has been generally heeded we should say that enough had already been written concerning the business management of the properties.

There is one feature, however, which in our estimation has not been adequately discussed, and that is the complete cessation of industrial research and of the development of natural resources of the territories served by the various railways. There has been a great deal of boasting over the "cutting down of unnecessary expenses," and if geological surveys and industrial departments are held to be "unnecessary expenses" we think it time to put a crimp upon the boasting.

There are many old and tried aphorisms which are sound in doctrine if intelligently applied; but when the same old saws are offered as excuses for doing the wrong thing they become about as vicious as German propaganda. The study of the resources along the line of a railroad is its first step in the recording of assets that may be made available. Sometimes it is a good while before such assets may be realized, but that is no reason why they should be neglected. We are reminded of certain successors to the late SIR WILLIAM PERKIN in the manufacture of dyes in England. They were intensely practical men. They had no time for such nonsense as intangible things. SIR WILLIAM'S extensive scientific library was not wanted. His arrangements with leading chemists in academic life were canceled. The chemists engaged in research were discharged. As long as they could keep good foremen in the works and were sure they had the right "formulas" they were satisfied. Then, before they knew it, they were being undersold with German goods in their home town, and in a few years more they were practically driven out of business.

This was not a distinctly British view that muddled the minds of those Englishmen to their undoing and the loss to their nation of a great industry. It was the same distorted view that is still all too popular in this country: the notion that anything that cannot be tagged with the dollar mark of so much cost and such and such a selling price is to be discarded because it involves unnecessary expense.

We do not profess to have valuable opinions about ton-mile costs, but we do claim to know something about raw materials. The railroads of the South, where an almost illimitable store of mineral treasure is to be found, were doing splendid work before the war by having the territories adjacent to their lines surveyed as to their natural resources. If this had not been done we should have been in more than one sore dilemma during the past four years. We regard it as no less than a national misfortune that work along this line should not only have been discontinued, but effectively prohibited, so far as the railways are concerned.

We thought the war had taught us the value of applied science in industry. It sometimes seems as if some of us had learned to repeat the slogan without understanding what it means.

An Appraisal of the American Potash Industry

AMERICAN potash producers are passing through worrisome times. Six months ago the cry arose from every hand, "Get us more potash." With the cessation of hostilities and cheap Alsatian salts in prospect, the fertilizer market is paralyzed. Barred from this most important outlet, some four months' output has heaped up, threatening to overwhelm the modest financial resources of many producers. Unquestionably this tonnage has largely been produced in good faith in response to the national need, and as such constitutes an informal obligation upon the Government that it be utilized without loss to the manufacturers or the consumers.

But what of the future? A continuance of the past inflated prices of fertilizer potash will pinch the consumer, raise the cost of many necessary farm products, and tend to maintain the high cost of commodities which is primarily responsible for the present commercial stagnation. Economically it is bad. Technically

it is indefensible; why should processes be perfected for more complete or cheaper extraction, or for the utilization of by-products, as long the sale of one portion will cover the cost of slipshod, wasteful and defective operation?

And so we wish to protest most emphatically against limitation of imports, a tariff "wall," paternalistic subsidy, or any like schemes of this sort to be vigorously pushed by interested persons, all of them making for high-priced potash. Lest we be damned as free traders out of pot, we hasten to give cordial support to the Tariff Commission and its underlying principle, popularized as the difference in cost, here and abroad. What we wish to emphasize right here, however, is that 75 per cent and more of our 1918 production was made by processes which can meet fair foreign competition, eliminating the bogey of "trade-war."

In 1918 natural brines produced 40,000 tons K_2O from plants aggregating double that capacity. Nebraska lakes alone yielded about 55 per cent of last year's output, at a cost estimated by us Nov. 15, 1917, at $40 per ton K_2O plus interest, amortization, profit and royalty. Figures of $110 per ton quoted by others must include large amortization allowances. Considering that the 1912-1914 price of German muriate f.o.b. American port was $65 per ton K_2O (even though it had been sold under trade-war conditions at a much lower price), it appears that the most important branch of our industry will need but a moderate tariff if coast-to-interior rail freights are established and the financial agreements are sound.

Our most promising immediate source of local supply lies in cement-kiln dust. It yielded but 1500 K_2O last year from installations rated at 3500 tons, yet if all cement plants would recover this product some 70,000 tons of K_2O would result. It is possible to build a plant to handle the gases and fine dust from a 1000-bbl. plant for $30,000, which by simple methods will collect 95 per cent of the volatilized potash. Such an installation has made potash at $50 per ton K_2O, which cost includes labor, power, repairs and renewals, interest and amortization, but does not include a proper and material credit for recovered slurry. Evidently here is an operation which can stand on its own feet. The failure of cement-makers to embark on potash recovery has been ascribed to the hesitation to make plant investments without more attractive returns, but the day will come when a cement kiln without its potash scrubbers will be as rare as a smelter without a dust chamber. Potash from iron blast-furnace dust also is a promising source, though possibly further in the future.

No industry should be permitted to maintain a high price for the benefit of an inconsiderable few of its own number and to the disadvantage of the consuming public, in the face of a low-priced international supply and an actual and prospective source of cheap substance at home.

Commodity Values and Construction Work

THE United States Government is engaged in an effort to bring about a resumption of construction activities in the country. This is a very progressive country and matters are so aligned that we are not busy unless we are engaged in a great deal of new construction. Our natural resources are so great and our labor is so efficient that nothing like all the labor is given employment if we are engaged simply in maintaining our facilities and producing the things that we currently consume. Also, we make so much money, such large profits, that we have in the normal year a great deal of new capital that must be invested or lie idle. New construction, therefore, is necessary if there is to be normal activity.

In the latter part of March the Industrial Board of the Department of Commerce, which is engaged in an effort to deflate war prices in the interest of stimulating construction work, reached an agreement with the iron and steel producers whereby certain reductions in prices were effected. The character and extent of the reductions, as well as of those which occurred last December, are referred to in the market report on iron and steel in this issue. Comparisons are frequently made with prices before the war, the favorite period being the ten years 1904 to 1913 inclusive. The investor may observe that prices at this writing compare with ten-year pre-war averages as shown below. Prices of the non-ferrous metals refer to the common brands, cents per pound at New York, while the steel price is a weighted average of the leading finished steel products, in cents per pound, Pittsburgh. The pre-war price is the ten-year average of quotations, 1904 to 1913.

	Pre-war	Present	Change Per Cent
Copper	15.36½	15.25	— 1
Spelter	5.84	6.52½	+12
Lead	4.64	5.20	+12
Aluminium	28.50	29.00	+ 2
Antimony	9.88	6.62½	−33
Steel	1.80	3.25	+81

Of the five non-ferrous metals cited three are higher than before the war, while two are lower. If one struck an average of the five there would be a net decline, but that would be misleading, since antimony is relatively unimportant. No one can ignore copper, however, which has experienced a complete deflation under a billion-pound stock on hand, which is some 600 million pounds in excess of normal stock.

Steel, however, is still nearly double its pre-war average. That is something very difficult to explain. The steel producers point out that labor is very high, and when reminded that rail mills are almost automatic, while the modern blast furnace is composed largely of "labor-saving" devices, they rejoin that it requires labor to mine the coking coal and the ore, to transport materials and to make the machinery which the furnaces and mills use. The argument is frequently received as conclusive, but when steel and the non-ferrous metals are set side by side it becomes very difficult to explain why the arguments that have been accepted to explain steel's 81 per cent excess over the pre-war average do not have some considerable application to the non-ferrous metals.

What is the investor going to do about it? The steel that sold at pre-war prices is sold. It is not available. The pre-war price is interesting only as it may possibly furnish a guide as to the course of the market in future, but if steel had to come down, why has it not done so? Being a construction material in particular, why has not the absence of any considerable amount of new construction in the past few months brought it down with a crash? The investor wants to know whether it will come down in future, whether he will save money by waiting. He also wants to know, and this is a point frequently overlooked, whether he would make money by investing, even if he could not save by waiting.

Readers' Views and Comments

Potash Recovery

To the Editor of Chemical & Metallurgical Engineering

SIR:—I desire to call your attention to two articles published in your issue of Sept. 26, 1918, during the Chemical Show, one by Dr. J. S. Grasty and one by Mr. Lynn Bradley.

Dr. Grasty, in his article, gives a table, on page 437, which he precedes by the following statement:

Table V, showing the cost of producing pig iron, depending on the kind of ore used, and the estimated results in potash recovery and profits therefrom by the erection of a Cottrell electric precipitator at a 200-ton iron blast furnace, was prepared in collaboration with Mr. Lynn Bradley, chief engineer of the Research Corporation.

In Mr. Bradley's article, in the same issue, a table on page 459 is preceded by the following statement:

The following table has been compiled to show the economic importance of these ores as a source of potash, the figures having been based on experience at several other furnaces as well as on the data obtained in connection with these particular ores and at various iron furnaces in the South. The table has been submitted to experienced blast-furnace operators for suggestions and criticisms.

I am attaching a table which, excepting for the last item, is an accurate reproduction of both of these tables, so that the figures obtained by each author may be compared. Dr. Grasty's figures are headed by the letter "G". Mr. Bradley's figures are headed by the letter "B".

It is quite evident that they both have started with the same coke and the same limestone, as their figures are identical for these two materials; that they both based their figures on the same Cambrian ore and on the same brown ore, as the analyses of the materials given by both of them are identical for both ores excepting that Dr. Grasty reports 6 per cent H_2O in the brown ore column, while Mr. Bradley reports 6 per cent of lime magnesia. The potash contained in the three ores is the same for both authors.

Based on exactly the same figures for No. 1 Cambrian ore and No. 3 brown ore, Mr. Bradley and Dr. Grasty arrive at different conclusions. While they both find the same total potash content per ton of iron for No. 1 ore, they arrive at different losses of potash in the slag and elsewhere for the same ore. Dr. Grasty deducts 20.96 lb. for the losses, while Mr. Bradley deducts 10.4 lb. Dr. Grasty, therefore, finds 78.54 lb. potash collectible, Mr. Bradley, 89.1 lb. from the same ore. In the No. 3 ore, the same sort of discrepancy exists. Dr. Grasty allows 23.46 lb. of potash for losses per ton of iron, while Mr. Bradley allows 14 lb. per ton of iron, so that Dr. Grasty, of course, figures 10.51 lb. of potash is collectible, while Mr. Bradley figures that 19.97 lb. of potash is collectible per ton of iron.

Dr. Grasty makes an estimate of return which shows that unless a furnace runs on No. 1 Cambrian ore, it can expect no net return from the potash collection. He estimates the annual operating cost of a precipitator at a 200-ton furnace at $165,000. Revenue from potash on a furnace running on No. 2 red ore and No. 3 brown ore is so small, according to Dr. Grasty's figures, that it could not possibly, even with a 40 per cent water-

	No. 1 Cambrian Ore		No. 2 Red Ore		No. 3 Brown Ore	
	G	B	G	B	G	B
Material cost, long ton	$5.00	.....	$2.00	.....	$3.50	.....
Content silica, per cent	19.20	19.20	18.00	15.00	19.50	19.50
Content alumina, per cent	4.80	4.80	5.00	4.00	3.80	3.80
Lime—Magnesia	1.30	1.30	18.00	17.00	6% H_2O	6.00
Potash	1.80	1.80	0.20	0.20	0.20	0.20
Iron	49.80	49.80	34.00	36.00	42.00	42.00
Ore required for one long ton of iron, lb	4,398	4,398	6,365	6,039	5,212	5,212
Percentage of burden	46.07	46.07	50.93	54.35	46.87	46.87
Coke required for one ton of iron, lb	2,700	2,700	4,480	3,900	3,000	3,000
Percentage of burden	28.29	28.29	35.85	35.22	26.98	26.98
Dolomite required for one ton of iron, lb	2,448	2,448	1,652	1,159	2,909	2,909
Percentage of burden	25.64	25.64	13.22	10.43	26.15	25.15
Material cost per ton of iron coke	$10.80	.....	$17.92	.....	$12.00	.....
Material cost per ton of iron-ore	$9.82	.....	$5.68	.....	$8.24	.....
Stone (dolomite 90 lb, limestone 100 lb.)	$1.09	.....	$0.74	.....	$1.30	.....
Total material cost for one ton of iron	$21.71	.....	$24.34	.....	$21.54	.....
Furnace capacity in tons iron output per day	230	.....	180	.....	220	.....
Total material cost per day	$4,993	.....	$4,381	.....	$4,739	.....
Average value per ton of iron produced	$33.00	.....	$31.50	.....	$33.00	.....
Gross value of output of iron per day	$7,590	.....	$5,670	.....	$7,260	.....
Gross profit on iron output per day (labor, etc., not considered)	$2,597	.....	$1,289	.....	$2,521	.....
Gross profit on iron output per year as above	$908,950	.....	$451,150	.....	$882,350	.....
Total potash content of burden per ton iron, lb	99.50	99.50	34.43	29.57	33.97	33.97
Deduct for losses in slag and elsewhere	20.96	10.40	31.28	15.60	23.46	14.00
Potash remaining, unknown portion, collectible, lb	78.54	89.10	3.15	13.97	10.51	19.97
Gross value potash at present price $5 per unit—350 days = 1 yr. operations:						
Equal to 25 per cent water-soluble	$395,154	.....	$12,403	.....	$50,579	.....
Equal to 35 per cent water-soluble	$553,216	.....	$17,364	.....	$70,811	.....
Equal to 40 per cent water-soluble	$632,247	.....	$19,844	.....	$80,927	.....
Estimated operating cost per annum	$165,000	.....	$165,000	.....	$165,000	.....
Estimated net value potash per annum—present 25 per cent	$230,154	.....	.....	.....	.....	.....
Estimated water-soluble 35 per cent	$388,216	.....	.....	.....	.....	.....
Estimated water-soluble 40 per cent	$467,247	.....	.....	.....	.....	.....
Slag volume per ton iron, lb	.....	2,715	.....	3,290	.....	3,090
Total potash in gases per day (500 tons iron)	.....	44,550	.....	6,985	.....	9,985
Total potash in gases per 350-day year	.....	7,796	.....	1,222	.....	1,747
Assume 80 per cent recovery	.....	6,237	.....	978	.....	1,40-
Value per annum at $500 per ton K_2O	.....	$3,118,500	.....	$489,000	.....	$703,00
Value per annum at $100 per ton K_2O	.....	$623,700	.....	$97,800	.....	$140,60
Value per annum per 100 tons iron at $5 per ton	$316,123	$623,700	$9,922	$97,800	$40,463	$140,60

	Coke		Limestone		Dolomite	
	G	B	G	B	G	B
Material cost, long ton	.....	.....	$1.00	.....	$1.00	.....
Material cost, short ton	$8.00	.....	.....	.....	.....	.....
Content silica, per cent	8.70	8.70	2.00	2.00	1.25	.....
Content alumina, per cent	5.00	5.00	1.00	1.00	1.00	.....
Lime—Magnesia, per cent	0.30	0.30	53.00	53.00	58.88	.....
Potash, per cent	0.30	0.30	0.30	0.30	0.50	.....
Iron, per cent	1.70	1.70	0.00	0.00	0.00	.....

soluble collection, show any profits from the potash value at the extreme price of $5 per unit.

Reducing this to a 100-ton basis, and comparing Dr. Grasty's figures for return at $5 per unit of K_2O with Mr. Bradley's figures reduced to the same basis, there is a very great discrepancy to be found. Dr. Grasty finds the revenue to be $316,123 per 100 tons of iron per annum, while Mr. Bradley finds a revenue of $623,-700. The latter figures are slightly less than twice the former figures. Starting with No. 2 ore, with very little difference in composition and having exactly the same potash content, Dr. Grasty finds a gross revenue of $9,922 per hundred tons of iron per annum for the potash, while Mr. Bradley finds, for the same conditions, $97,800 revenue. The latter figures are nearly ten times the former. For No. 3 brown ore, Dr. Grasty shows a revenue of $40,463, while Mr. Bradley shows a revenue of $140,600. The latter figures are nearly four times the former.

Since Dr. Grasty comments that his table was worked out in co-operation with Mr. Bradley, it is worth while finding out how these two authors, in two papers, came to such extremely different results. Mr. Bradley's figures for potash content for ores No. 2 and No. 3 compared with the losses that he allows for these two ores check with results obtained by us in actual electrical precipitation tests on a semi-commercial scale. The ratio between his loss and the total potash content is similar to the ratio we have found. I cannot understand Dr. Grasty's deduction in ore No. 2 of 31.28 lb. out of a total of 34.43 lb. Given the same operating conditions on all three ores, even if the slag volume varies, I cannot conceive of any reason why there should be such a tremendous difference. I believe that for the No. 2 and No. 3 ores, Mr. Bradley's figures of losses approximate the actual conditions. For No. 1 ore, I hardly believe that either the figures of Dr. Grasty or Mr. Bradley are correct. It is evident that there has been an assumption that the same percentage of slag would be potash for all three ores, the lean and the rich.

Tests made by us on ferromanganese furnaces indicated that when the ores are richer in potash, the greater is the amount of potash lost in the slag. I am, therefore, of the opinion that no such condition as indicated by Messrs. Grasty and Bradley exists in actual practice. Our tests, while not conclusive, have led us to believe that with a rich ore, such as shown in No. 1 Cambrian, there is a loss of about 50 per cent in normal blast-furnace operation of the potash, while the other 50 per cent is recoverable. I believe, however, that this loss can be cut down to 30 per cent by proper methods of treatment.

In connection with the costs, information obtained by us in running semi-commercial tests indicates that the cost of operating precipitators for a 200-ton blast furnace is nearer $70,000 per year than $165,000. Per hundred tons of iron per annum the chargeable expense to the potash collection would be about $35,000. This would make the cleaning of gases on furnaces running on ores as poor as Nos. 2 and 3 a very profitable undertaking. For No. 2 ore, based on Mr. Bradley's figures of gross revenue, the net returns would be about $62,-000 per hundred tons of iron per annum, while on No. 3 ore the returns would be a little more than $105,000 for the potash per hundred tons of iron per annum.

The days of $5 per unit potash are about over. There will be a natural tendency to determine what might be the profits on a $1 per unit basis. Our figures for operation are about $42,000 a year for a 200-ton furnace when potash sells at $1 per unit. This difference is due to the smaller royalty paid on the cheaper potash. At that rate, the operating expense per hundred tons of iron per annum is $21,000. The practice is to run on ores running much higher in iron than No. 2 red ore, and the general practice is closer to the ores shown under column No. 3 brown ore. With potash selling at $1 per unit, according to Mr. Bradley's figures for No. 3 brown ore, which I believe are correct, there will be a revenue of $28,120 per hundred tons of iron per annum for the potash content in the dust recovered by electrical precipitation. This will yield a net revenue of over $7,000 per hundred tons of iron per annum for the potash recovered. There are a number of furnaces, however, running on a much richer ore.

While we have not completed our examination and we cannot therefore make the following as a definite statement, our initial analyses show that a brown ore in the South is running about or close to 1¼ per cent of potash. This ore also runs over 47 per cent of iron.

It would seem from Dr. Grasty's figures that there are no potash values to yield a net revenue even at $5 per unit from either the No. 2 or the No. 3 ore, while the revenue from the No. 1 ore is considerable. If the corrections as designated above were made, the No. 1 ore would yield a revenue about one-third less than shown in Dr. Grasty's figures.

I cannot understand, however, how these two authors drifted so far apart in their final conclusions when using practically the same original data and working in collaboration with each other.

N. H. GELLERT.
Philadelphia, Penn.

An Example of Crystal Crushing

To the Editor of Chemical & Metallurgical Engineering

Sir:—In your issue of Jan. 15 on page 72 appears a short article on "An Example of Crystal Crushing," in which the author states his opinion that the gray or silky spot usually seen in the center of the otherwise crystalline fracture of a medium-carbon steel test-bar is due to the fact that "the crystals in the interior of the bar were crushed during the elongating of the bar before rupture." The gray spots mentioned have often been seen in tensile tests of good-quality rails in this laboratory and have been the subjects of microscopic examinations. These examinations have always shown that there was no greater crushing or distortion of the crystals in the metal that had the gray fracture than there was in the metal with the crystalline fracture. Since the gray spots were always seen only in steel that contained an appreciable amount of ferrite, while steel without ferrite had a purely crystalline fracture, and steel composed chiefly of ferrite had a fracture that was all gray or silky, the opinion was formed here that the gray part represented a slow separation through ferrite, while the crystalline part of the fracture repre-

sented the final instantaneous break through the cleavage planes of the pearlite.

This, of course, does not explain why the silky or supposedly ferrite fracture should occur only at the center of the bar, when the microstructure was found uniform throughout, as it usually was. A consideration of the effects of the reduction of area, however, which accompanies all elongation of test-bars, may explain this. When the test-bar is elongated the outer particles of metal move not only lengthwise, but also inward toward the central axis, and as the circumference of the bar contracts the outer particles must move past each other to permit this contraction. Thus near the surface of the bar the increase in length is partly taken up by a sidewise rearrangement of the particles, while at the center the contraction is practically nil and the elongation is effected more largely by straight lengthwise movement of the particles. For this reason the tensile strains at the center are such as might be expected to cause fracture of the ferrite, being the weaker constituent of the metal, while nearer the surface the inward flow of metal would prevent the ferrite from breaking. Finally the inner fracture would become so large that the outer metal, even though hardened by slipping, could no longer sustain the load, and it would then break suddenly through its cleavage planes, giving a crystalline fracture. In other words, the formation of the silky center with crystalline rim is considered analogous to that of the common cup fracture of soft steel, with its gray silky center and sloping sheared rim. This explanation is believed to be more reasonable than one based on an assumed central crushing, which is not actually observed to be any greater than the normal distortion of the metal near the surface of the fractured test-bar.

GEORGE F. COMSTOCK.
Titanium Alloy Manufacturing Co.,
Niagara Falls, N. Y.

Future of the Potash Industry

To the Editor of Chemical & Metallurgical Engineering

SIR:—What of the future of the American potash industry? Certainly it has been shown that American resources are adequate to supply American demands. But will these be further developed, or will the potash monopoly be handed back to Germany? If the public —the Government—now that the international crisis is over, loses its interest in the domestic industry and surrenders the trade to the unrestricted hands of those who operate without regard to the public weal or American commercial independence, without sentiment, potash will be purchased where it can be obtained the cheapest. And German potash, if admitted without restrictions, will be the cheapest potash. German subsidies will see to that.

It is said that Germany, to meet her financial obligations, will be forced to place an export tax on such commodities as potash, which will operate to maintain a high price for German potash. It must be remembered, however, that before an export tax on potash can be paid, potash must be exported; and before it can be exported, it will have to be re-established in foreign markets. For its re-establishment a low price must be its first requisite. There seems to be no reason to believe that the policy of the potash industry of Germany and the Government, with which German industry is closely allied, which prompted them to spend millions in potash propaganda abroad, will be reversed. It would appear that its exportation would now be of even greater importance than ever before.

The late military war was won by science, organization and efficiency. It was demonstrated that without these the man power combined with the wealth of the world was not sufficient. The victory that is now America's is America's only because she applied her science as an organized and efficient nation. With even greater emphasis can it be said of the trade war that is to follow the late military war that victory will be America's only in so far as we, her citizens, apply our science as an efficient organization, not as a heterogeneous mass of competing individuals. We have already made tremendous strides toward efficiency in insisting that a man purchase and use as little as he possibly can, not all that his credit will allow, and in the placing of curbs on the operations of the profiteer, the pooling of interests and the elimination of competition (which is the root and branch of inefficiency). These gains, which the President speaks of as "the by-products of war," must be retained and tremendously enlarged if we are to emerge from the second war with victory.

This efficiency, which will involve organization, coordination, co-operation, will consider waste on the one hand, both of labor and materials, and unused resources on the other. This will involve American potash in two ways. First, potash as a by-product (or with the aid of by-products) will become a permanent reality. Second, more conservativeness will be exercised in its use. We have been watching with interest the results on American agriculture of a great curtailment in the use of potash fertilizers. We have been asking ourselves how much the former wide and indiscriminate use of potash is based on actual scientific experimentation on American soils and how much on German propaganda.

American agriculture, formerly educated through German propaganda to the use of muriate and sulphate, with very little experimentation to determine the facts for itself, now finds itself applying to agricultural use a great variety of potash salts from a great variety of sources. There is a carbonate and sulphate from the alkali lakes of Nebraska, muriate from Searles Lake and kelp, carbonate from wood ashes and tobacco stems, and sulphate from alunite, cement mills, beet sugar residue and molasses. These are mixed in varying proportions with lots of other things present as impurities, and of questionable, if any, value as fertilizer. It has been a matter of ignoring ancient projudices in many cases or of doing without potash.

For example, muriate has been regarded as impossible for tobacco, and there potash has been regarded as a necessity. Are the tobacco growers using muriate, or are they doing without potash altogether where sulphate is not available? Does the presence of the small amount of borax found in muriate from certain sources act as a soil disinfectant and kill the soil bacteria essential to plant growth, or does it act as a stimulant, as poisons in small quantities so frequently do, and stimulate the growth of soil bacteria and thereby plant growth? Has the prejudice against muriate in California foundation in fact, or is it advice tendered by the German Kali Syndicate to the American farmers because sulphate formerly was produced only in Germany, and its use in our soils insured the use of German potash in place of local potash? It is unmistakable that there is a prejudice in California, for instance, against the use of muriate, the idea having been conveyed that

muriate contributed to the formation of alkali. It has not been possible to trace this idea to any experimentation actually performed by Californian experimentalists on Californian soils. It *has* been possible, however, to trace it to German propaganda. Knowing what we do about the nature of alkali in the soil and German propaganda, the question must be answered: Is not the Californian agriculturist making a mistake when he imports potash from Germany while ignoring the immense sources of potash at his own door?

Too much that is fundamental is involved in German science for us to question it without other reason than our late fear and hate of German world ambitions; but this we can surely say, that German propaganda has been written from the point of view of German profit.

J. W. TURRENTINE.

Summerland, Calif.

Application of Nitro-Aromatic Compounds in Explosives Industry

To the Editor of Chemical & Metallurgical Engineering

SIR:—Two years ago I pointed out in your columns, March 15, 1917 ("The Application of Nitro-Aromatic Compounds in Explosives Industry"), that when the price of raw materials used in military explosives such as toluol and carbolic acid would drop from the abnormal prices of war to pre-war prices, it would be a good chance to convert TNT and picric acid into commercial blasting explosives. At the present time toluol and carbolic acid may be obtained at 18c. per gal. and 6c. per lb. respectively, and converted into TNT and picric acid at a respective cost of 10 to 12c. per lb. These purely military explosives cannot be used directly in commercial work, so it may be necessary to dilute and bring them to the grade of other standard blasting powders, like 40 per cent and 60 per cent standard dynamites, and at the same time eliminate the objectionable gases by mixing with oxidizing materials.

Thus there is a good opportunity for the picric acid and TNT manufacturers to continue making these nitro-aromatic compounds, by trying with a mixing outfit to convert these into commercial blasting explosives. The chance of success in explosive lines is much brighter than in the dyestuff business, which is almost overdone at the present time and does not present as big a future, commercially speaking.

During this period of waiting and readjustment it will be a good move on the part of TNT and picric acid manufacturers to investigate the possibilities of this proposition and to start preliminary tests and investigations on the properties and the powers of these new explosives. I have no doubt that they will find explosive engineers of tried experience and knowledge who will gladly co-operate with them in the application of TNT and picric acid to the explosive industry.

J. R. MARDICK.

New York, N. Y.

High Stacks for Smoke Dissipation

To the Editor of Chemical & Metallurgical Engineering

SIR:—I notice in your editorial on "The Metallurgy of Copper in 1918" (Jan. 1, 1919) that you speak of high stacks and the resultant smoke dissipation as a recent development of Mr. O'Gara. The old 300-ft. stack on top of the hill at Anaconda, which carried the smoke 1000 ft. above the valley and 500 ft. higher than the tops of the original stacks, was built for this very purpose, as the reports made at that time will show. This stack and the long connecting flue were built on my recommendation and as a result of my investigations made for the Anaconda company in 1903. It was soon followed by the construction of the 500-ft. stack at Great Falls for the same purpose of smoke dissipation. It is needless to mention that the new stack recently completed by the Anaconda company, and much larger and higher than the old one, has been built on top the hill alongside the old one.

In passing I might say that the tremendous development of the reverberatory furnace to almost its present size and efficiency immediately followed the completion of the Anaconda stack and can be traced directly to its operation.

I do not wish to detract in the least from Mr. O'Gara's work, but it is only fair that credit be given to the pioneer work in this direction, which was done some time before the Cottrell process was invented.

STUART CROASDALE.

Denver, Colo.

A Great Opportunity for Intelligent Location of Industries

To the Editor of Chemical & Metallurgical Engineering

SIR:—With the sudden emergence of the United States from a secondary political position to that of a world power, we have had thrust upon us one of the greatest opportunities for internal development ever placed before our people. The natural resources of our country are the envy of the world. Agriculture, mining, manufacturing and transportation flourish side by side and ever on an increasing scale. Abroad, however, we are known as producers of raw materials, principal among which are cotton, wheat, steel, meat and petroleum. Our manufactured products go largely to a home market—not more than 8 per cent of those produced in 1915 were exported.

It has been a creditable performance to export a large tonnage of raw materials to the artisans of Europe. Their distribution through the markets of the world as finished products by laborers of other countries is to our national discredit. It was very natural that masters of ships subsidized by their home Governments should carry the manufactured articles made by their own people and that export trade in articles manufactured in the United States should languish. But we are promised better treatment!

American shipping calling at the principal ports of the West Indies, of Mexico, South Africa, South America and the Orient is ready to carry our commodities to all of the great markets of the world. Our broadened national policy is particularly interesting to the manufacturer. Raw materials may be worked into their ultimate products at home, giving employment to many people and adding greatly to our national wealth and influence. To meet the situation we need to enlarge our existing plants and to add scores of new industries wherever conditions are favorable for their maintenance.

The modern American city is the nucleus of successful manufacturing and the phenomenal growth of 90 per cent of the towns of the United States is due to a recognition of this fact. There are about 175 cities in the United States each with a population of more than 25,000. Every one of these towns is a good location

for *one* or *more* industries and the *best* economic *location for at least one.* This may be due to the presence of an important raw material, a remarkable climatic condition or an unusual market. The iron ore industry of Duluth is an example of the first; the growth of the moving picture business at Los Angeles is an example of the second; and the Alaskan trade controlled by Seattle illustrates the third.

No other branch of industry can excel manufacturing from a labor standpoint. Employment is usually constant throughout the year. Both male and female help is utilized and under our present financial system, payment is prompt, with a fair wage. Capitalists and bankers are eager to lend financial support to a legitimate manufacturing business, and expect a good return upon the investment, if it is well managed. Examples of remarkable dividend paying enterprises are the well established cotton mills of New England, the steel plants of Pittsburgh or the various plants of the General Electric Co. The average annual sales of a stable manufacturing business are usually about equal to the capital stock invested and the net income in many instances averages 20 to 25 per cent.

The accumulation of sufficient wealth conservatively invested to insure leisure tempts thousands of men to move into small cities, where they live useless and comfortable lives. If such men dictate the policy of a town it is placed on the traveling man's map as "dead." There are hundreds of such places pretty well distributed throughout our national territory. In the country roundabout, the wealth that the Creator placed in the ground remains unsought for, the land is aimlessly tilled, and the fruit rots on the trees.

We have just emerged from national scarcity of many things, and the lesson should awaken every live man of influence to a sense of responsibility and to line up the raw materials and the men and women of his locality to produce useful manufactured commodities for the people of the world. One good industry employing a thousand people will transform a self-sufficient "retired business men's" town into a thriving village or city. One live man can make this change, with proper backing from the controlling financial forces.

Until very recently bankers have preferred to handle real estate and mortgages than to lend to manufacturers. In many instances, foreclosures on mill property have been the direct result of a short-sighted system of discrimination against even the best commercial paper. A bank is a public institution, one of the purposes of which is service to the community. If manufacturing has not been popular among the business men of a town it is the duty of the local banks to employ technical assistance, and determine what can be made and sold to advantage in that locality. With proper financial support a plant may be erected and a business started.

While the banker has been conservative in industrial matters, our business men of many cities have combined forces and have, through their commercial associations, attracted industries that have enriched the life and business of the town in every way.

We foresee an intensive study undertaken by every municipality to determine what can best be manufactured in that place. We remember Schenectady as a sleepy cobblestone-paved town of 12,000 people. The presence of an industry of national scope and interests has made a modern city of nearly 100,000; 25,000 of these are men and women who earn good wages with one concern.

If a town has grown through the manufacture of a raw material the supply of which will soon be exhausted, the public spirited citizens of the place should attempt to find a substitute before the actual death of the business. The sawing or handling of lumber is an example. Many prosperous mining towns of the West are depopulated when paying ore ceases to be found.

Among the fundamental elements of a location to be studied are the following:

Raw Materials	Climate
Market	Hygienic Conditions
Transportation	Public Utilities
Labor	Housing
Water Supply	Banking Facilities
Power Cost	Taxes and Insurance

Education and Public Spirit

For some reason not at first evident the greater portion of the manufacturing of the United States is carried on within an area bounded by lines connecting Portsmouth, N. H., Milwaukee, Wis., St. Louis, Mo., and Baltimore, Md. Since 1850 manufacturing investments in this territory have increased from a few hundred millions to more than twenty-five billions. The general reason for the growth in this limited area is the adaptability of the people to the climate and topography, with ample fuel and raw material supply. Intelligent white labor lives and thrives in a belt about two hundred miles north and south of the fiftieth isothermal degree from the Atlantic to the Mississippi River. Colored labor, Mexicans and the Japanese are available in the warmer sections of the country, so that it is possible to operate a plant irrespective of the latitude. Any town in the United States located on a railroad may have some natural product that can be manufactured into a useful material for home market or export.

Our climate varies from semi-tropical to cool-temperate. A business that requires much sunshine may be located in New Mexico, Arizona or California. For cotton manufacture, a high relative humidity is found along the Atlantic and Gulf coasts; if high altitude is essential this may be found in Salt Lake City, Denver and Cheyenne.

But natural elements are not all. The temper of a city is told by the spirit of its people. No prospective manufacturer wants to try to do business in a town which is itself antagonistic or indifferent. The founders of what has become a manufacturing business of national scope asked the leading men of a conservative Eastern city if they might locate a plant in that place. A negative answer was given, with the comment that "their town did not want the noise and smoke incident to the enterprise." It often occurs that the lives, happiness and well being of 10,000 people depend upon the main industry of the place.

A careful location study includes the foregoing and much more. Given the selection of a manufacturing site for a large industry, all good location areas should be investigated, and that one selected which seems to embody the greatest number of favorable factors.

WILLIAM MILLER BOOTH.

Syracuse, N. Y.

Report of Alien Property Custodian on the Metal Industry

CHAPTER III of the report recently made by the alien property custodian to the President contains a great many interesting revelations regarding the German domination of the metal markets of Europe, particularly those of zinc and lead. The intricate relationships existing between the numerous German-owned or controlled companies are shown graphically in the accompanying drawings.

While Germany has never been a great producer of metals, yielding only 3 per cent of the world's copper, 28 per cent of the refined zinc and 16 per cent of the lead, yet she has exercised almost complete control of the zinc and lead markets of the world outside the United States. The alien property custodian finds the secret of this power in the fact that the great German metal houses have acted in concert in the purchase of zinc and lead ores, control of smelters and refineries, and have been favored by unlimited credit from German banks.

The German metal triumvirate are the Metallgesellschaft of Frankfurt, Aron Hirsch & Sohn of Halberstadt, and Beer, Sondheimer & Co., of Frankfurt. These vast concerns developed out of very small ventures.

(1) *The Metallgesellschaft* is the largest of these concerns and is by far the most powerful metal concern in the world. It is a stock corporation with a capital of 18,000,000 marks. It is the outgrowth of the metal business founded by Philip Abram Cohn early in the nineteenth or late in the eighteenth century. In the early '60s of the last century, Henry Merton, whose real name was Moses and who was related to Philip Abram Cohn, founded a metal firm in London which later became the powerful house of Henry R. Merton & Co., Ltd. The Metallgesellschaft and the Merton firm worked hand in hand for the advancement of German domination of the metal markets of the world.

(2) *Aron Hirsch & Sohn*, a copartnership, is the business founded by Aron Hirsch and it has always been kept in the Hirsch family. This house has not confined itself strictly to metal trading but has also engaged in metal manufacturing. It has interests all over the world.

(3) *Beer, Sondheimer & Co.*, a copartnership, was founded in the latter part of the '70s by Messrs. Beer and Sondheimer, two salesmen of Metallgesellschaft, who broke away from the Metallgesellschaft and with the assistance of the Mitteldeutsche Credit Bank started in business for themselves under the name of Beer, Sondheimer & Co. This firm has confined its activities principally to the zinc smelting business.

The Zinc Syndicates

At the outbreak of the European war these three concerns controlled the zinc industry of the world with the exception of the United States. The control of the purchase of Australian ores was exercised by means of joint accounts resulting in the elimination of nearly all competition both in the purchase of ore and its allotment to European smelters.

This Australian zinc-ore purchase combine was followed by the formation of the German Zinc Syndicate, comprising all the large zinc concerns of Germany for the purpose of fixing prices in Germany. The formation of this syndicate was met by the formation of an English syndicate and a Belgian-French syndicate. The most important Belgian concern, however, the Société Vielle Montagne, which had extensive works throughout the world, was in a working agreement with the German Zinc Syndicate, so that the latter's preponderance over all the others was so great that they were forced to join the Germans in the formation of the International Zinc Syndicate in 1911. The purpose of the syndicate is stated as follows:

> A curtailment of production is to be effected whenever the stocks held by the various zinc smelters at the end of a quarter exceeds 50,000 tons; provided, however, that if the price of spelter in London should be £23 or more no curtailment of production is to take place.

Production and price were regulated and agreed upon from time to time according to the necessities of the market. The sale of the metal was placed in the hands of three principal German concerns which the alien property custodian designs as the triumvirate.

The Lead Syndicate

At the outbreak of the European war the lead output of the world was likewise centered in the hands of the Germans. The Metallgesellschaft had the exclusive sales agency of what was known as the international lead convention, which was formed in 1909 and continued thereafter for a number of years. It embraced the principal Australian lead producers, as well as most of the German, and most of the Spanish and Belgian lead mines. At least two American firms, to wit, the American Smelting & Refining Co. and American Metal Co., as far as their production of lead from ores imported in bond is concerned, and some of the Mexican mines, were likewise members of the syndicate which regulated output and fixed prices.

Copper

The situation in copper, however, was quite different, and the Germans were never able to get control of production. This was due largely to the fact that the United States output, which is more than 60 per cent of the world's total, could not be brought under German domination. Outside the United States, however, the Germans largely controlled the copper output. Germany also exercised a powerful influence over the price of the metal through the activities of the metal triumvirate, as well as because she was a large consumer.

The power which these concerns exercised in the market is believed to lie in the unlimited credit at their command for financing large purchases of copper for long periods of time, including periods of depression.

The German Metal Triumvirate in the United States

At the outbreak of the European war each member of this triumvirate had a branch of its business in the United States. The Metallgesellschaft had the American Metal Co., Aron Hirsch & Sohn had L. Vogelstein & Co., and Beer, Sondheimer & Co. had a branch under its own name. All these branches were located in New York City, and all developed vast and extensive interests in the United States, Mexico, and South America, including the control of mines, smelters, and refineries.

(*a*) *American Metal Co., Ltd.*—In or about the year 1887 Metallgesellschaft sent to the United States two of its representatives, to wit, Jacob Langeloth and Berthold Hochschild, to establish a branch of the Metallgesellschaft's business. At that time the present banking firm of Ladenburg, Thalmann & Co. were doing a metal business and had connections with the Metallgesellschaft. An arrangement was made resulting in the organization of a corporation called the American Metal Co., Ltd., under the laws of the State of New York, with a capital of $200,000, divided into 2,000 shares, to which corporation Ladenburg, Thalmann & Co. turned over their metal department. The stock of the corporation was issued as follows:

	Shares
Metallgesellschaft	600
Henry R. Merton & Co.	595
Ladenburg, Thalmann & Co.	710

The balance of the stock was allotted to various officers. It will be noted that from the very organization

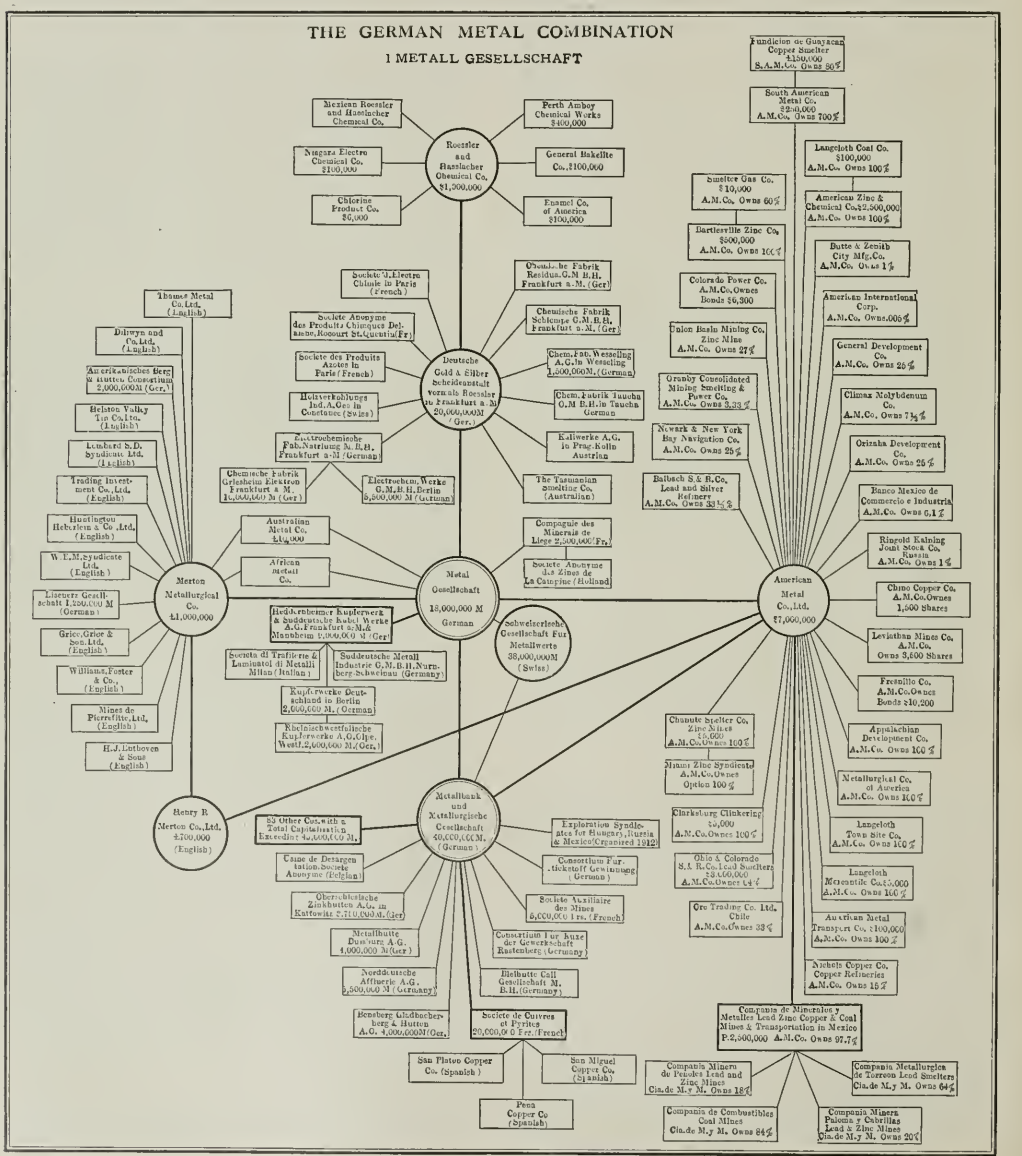
of the American Metal Co. the stock control thereof was in the hands of Henry R. Merton & Co. and the Metallgesellschaft. These German interests continued to retain that control through all the years of the development of the American Metal Co., and had the control at the outbreak of the European war. The capital stock of the American Metal Co. was increased from time to time until in 1917 it was $7,000,000.

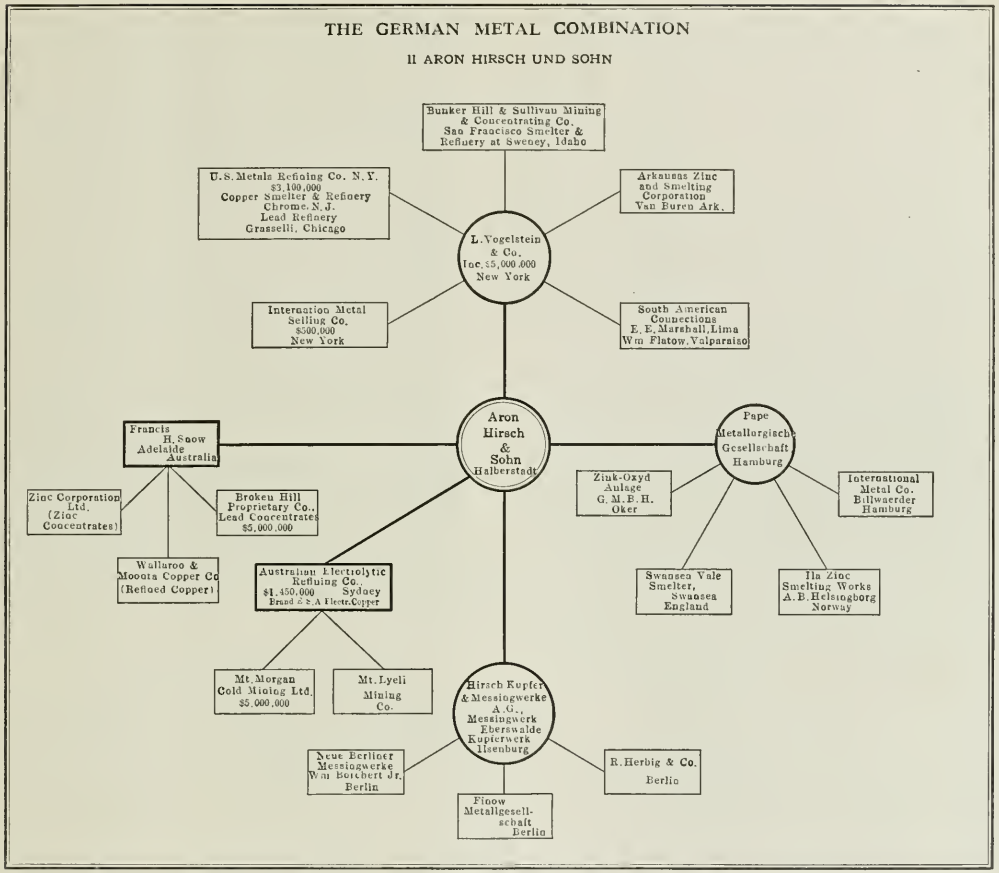
The entire turnover of the company in copper is about 250,000,000 lb. per annum, which is about 15 per cent of the country's total production of copper.

The report of the alien property custodian gives the following statements of average annual quantities of products of the American Metal Co.

Electrolytic copper	100/125,000,000 pounds
Zinc (spelter) all grades	75/100,000 tons
Bonded (Mexican) lead	50/75,000 "
Domestic lead	12/15,000 "
Sulphuric acid	80/100,000 "
White arsenic	4/6,000 "
Coal in Pennsylvania	350/400,000 "
Coal in Mexico	500/600,000 tons
Silver	12/15,000,000 ounces
Zinc oxide (Polar and Arctic brands)	7/10,000 tons
Zinc dust (American Extra Pure and Zenith brands)	3/4,000 "
Antimonial lead	1,000/1,500 "
Molybdenum concentrates	500/1,000 "

The zinc ores purchased by the American Metal Co. and treated by the smelters of its domestic subsidiaries for the two years ended June 30, 1917, amounted to approximately 1,700,000,000 lb. In addition to that





the company purchased spelter during those 2 years in the open market amounting approximately to 585,000,000 lb. The production of lead for 1917 was 168,000,000 pounds.

(*b*) *L. Vogelstein & Co., Inc.*—Aron Hirsch & Sohn was 10 years behind the Metallgesellschaft in establishing a branch in the United States. In 1897, Ludwig Vogelstein started an agency for Aron Hirsch & Sohn in New York. Soon thereafter Vogelstein formed the firm of L. Vogelstein & Co. and associated with himself one Ernest G. Hothorn. In the firm Aron Hirsch & Sohn had a direct interest. The business was conducted as a copartnership until the end of 1916, when the present corporation, L. Vogelstein & Co., Inc., was formed. During these 19 years the Vogelstein business was conducted purely as an agency of Aron Hirsch & Sohn. There were agreements between Vogelstein and the Hirsch concern for the division of profits upon the American business and upon some of the European business.

The more important activities of the Vogelstein concern comprised the erection of a copper refinery at Chrome, N. J., in co-operation with Capt. J. R. DeLamar; the organization of the International Metals Selling Co. to facilitate the sale of the refinery's product; and arrangement with the American Zinc, Lead & Smelting Co. for the sole sale agency of that concern; the organization of the Arkansas Zinc & Smelting Corp. and the erection of a zinc smelting plant; and contracts with other smelters and refineries for exclusive selling agencies.

The total annual turnover during the last five years was as follows:

Copper (870,931,737 lb.)	$207,196,741.36
Gold (578,138,191 oz.)	11,870,104.67
Silver (25,120,134.16 oz.)	17,166,113.45
Lead (323,099,014 lb.)	18,320,735.68
Spelter (397,740,356 lb.)	47,814,011.40
Tin (91,128,623 lb.)	37,035,647.83
Miscellaneous	3,134,834.31
	$342,538,188.70

(*c*) *Beer, Sondheimer & Co., Inc.*—Beer, Sondheimer & Co. of Frankfurt established a New York branch in 1906. Like the Metallgesellschaft, it sent over two young men, Benno Elkan and Otto Frohnknecht, who established the business here under the name of Beer, Sondheimer & Co., American Agency. The name was subsequently changed to Beer, Sondheimer & Co., American Branch, and the business was conducted under that name until August, 1915, when it was incorporated, under circumstances which will be hereinafter discussed. The New York business was owned at all times by the Frankfurt house, Elkan and Frohnknecht being only agents upon a salary and a profit-sharing basis. The ramifications of the company in the metal business are shown in the chart.

The following table shows copper, spelter and lead turnover of Beer, Sondheimer & Co. for several years:

TOTAL TURNOVER

	Lb.	Value
Spelter dealt in:		
1915	73,143,943	$8,118,004
1916	75,563,802	10,342,882
1917	57,459,556	5,330,090
1918	49,814,465	4,131,826
Total	255,981,766	$27,922,802
Lead dealt in:		
1915	6,210,758	278,716
1916	5,754,419	378,096
1917	6,230,411	527,232
1918	673,727	70,539
Total	18,869,315	$1,254,583
Copper dealt in:		
1915	17,071,632	2,559,490
1916	24,295,095	5,530,191
1917	27,056,933	7,326,273
1918	10,450,315	2,627,004
Total	78,873,975	$18,052,958

Minerals-Separation Agency

The history of Beer, Sondheimer & Co.'s activities in the United States would not be complete without mentioning its connection with the various minerals-separation companies.

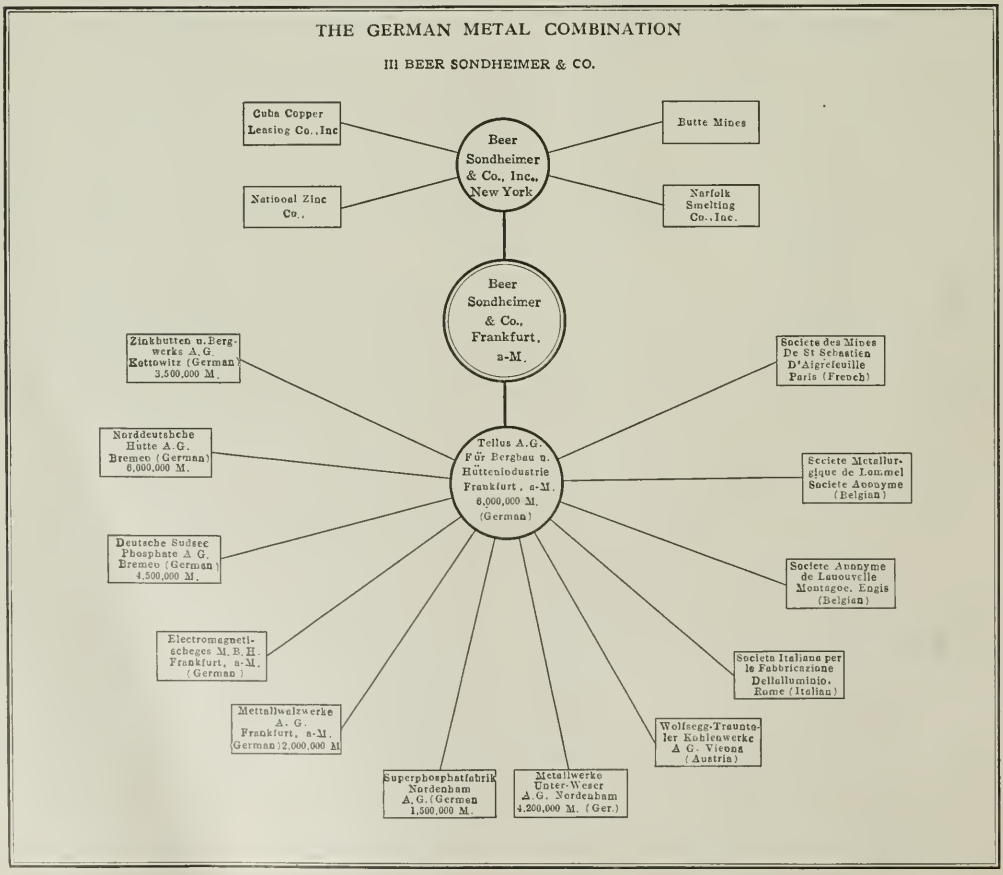
In 1906, Henry Livingstone Sulman, Hugh Fitzalis, Kirkpatrick Picard, and John Ballot, all of London, England, claiming to be the inventors of the new process, obtained a patent thereon in the United States. In 1910, Sulman and Henry Howard Greenway and Arthur Howard Higgins, all of London, obtained another patent in the United States, and in 1914, Greenway, then of Melbourne, Australia, obtained a third patent in the United States, the latter two patents involving the same process as the first one, but including improvements thereon. These patents run for a period of 17 years from their respective dates.

In 1905, and before the first United States patent was obtained, the patentees obtained a patent in England exactly similar to the first United States patent. The validity of the English patent was attacked in the English courts, but was sustained by the House of Lords. (Minerals Separation, Ltd. vs. British Ore Concentration Syndicate Ltd., 27 R. P. C., 33.)

In 1903, Minerals Separation, Ltd., which will be hereafter designated as the parent company, was formed under the English law. The three United States patents were assigned to this company.

In 1910, the parent company having acquired the United States patents, and similar patents obtained in Canada and Mexico, conveyed these patents to a corporation called Minerals Separation American Syndicate, Ltd., for the purpose of enabling the American syndicate to exploit these patents in America. This, too, was an English corporation.

In 1911 the American syndicate made a contract with Beer, Sondheimer & Co., whereby it gave to that firm the exclusive agency to represent the syndicate in America. For reasons which are unimportant to the present inquiry, this first American syndicate was soon dissolved and a new syndicate was formed, called Minerals Separation American Syndicate, 1913, Ltd. This, too, was a British company. The 1913 syndicate renewed the agency agreement of Beer, Sondheimer & Co., and appointed that firm sole agents to conduct all



of the syndicate's commercial affairs in the United States, Canada and Mexico, the agency to continue for a minimum period of 10 years with a provision for renewal for the rest of the life of the patents. Beer, Sondheimer & Co. were to receive a commission of 10 per cent of all gross royalties received for the use of the patents and 10 per cent on all profit-sharing business (the syndicate intending not only to give licenses, but also to buy up and treat ores), and also a percentage as a commission of the sale of products so treated by the syndicate.

When the agency agreement was made Beer, Sondheimer & Co. had an American branch of its business in New York City, which was in charge of Benno Elkan and Otto Frohnknecht, and was being conducted under the name of Beer, Sondheimer & Co., American Branch. The parties entered into the performance of the agreement, and inasmuch as most if not all of the business was done in the United States the agent's end of the business was conducted by the American branch of Beer, Sondheimer & Co.

In addition to having the exclusive agency, Beer, Sondheimer & Co. were also stockholders of the 1913 syndicate, owning 32,615 shares of said stock. In 1916 the property of the 1913 syndicate was conveyed to an American corporation called Minerals Separation North American Corporation, and each stockholder became entitled to two shares of the American corporation's stock for each share of the 1913 syndicate stock.

The importance of the control by this German-owned branch of Beer, Sondheimer & Co. of the minerals-separation process, and the power to grant or withhold from the United States metal-industry licenses to use the flotation process, can hardly be overestimated. The custodian, as will be pointed out later, has taken over all of the minerals-separation stock held by Beer, Sondheimer & Co., and the latter's control of the minerals-separation process in the United States has broken.

Disclosures by Investigations Conducted by Alien Property Custodian

After the passage of the trading with the enemy act in October, 1917, and the subsequent appointment of the alien property custodian, he caused investigations to be made of the American Metal Co., Vogelstein & Co., and Beer, Sondheimer & Co., as a result of which he took over the entire business of Vogelstein & Co. and of Beer, Sondheimer & Co. and 49 per cent of the stock of the American Metal Co. The investigations disclosed the following state of facts:

As to Beer, Sondheimer & Co. it was shown that legal subterfuges were adopted for the express purpose of making it impossible for the United States Government in case of war between the United States and Germany to exercise its belligerent rights and take control of enemy property in the United States. It was further disclosed that Messrs. Elkan and Frohnknecht were citizens of the United States; they did not become such until 1917. One of them became a citizen after Von Bernstoff got his passports and the other after we were at war with Germany. "There is evidence to indicate that their sudden desire to embrace our citizenship was only a 'war measure' after all and that they asked for and obtained the approval of the Frankfurt firm to their action."

As a result of his investigations the alien property custodian demanded and took over the entire business assets of Beer, Sondheimer and Co. as German property.

As to L. Vogelstein & Co., the alien property custodian has taken control of the business and is in possession of the entire capital stock, including the interest of Aron Hirsch & Sohn.

As to the American Metal Co., the alien property custodian demanded and received all of the 34,644 shares of stock owned by the Germans and appointed 5 out of the 15 directors of the company to represent him in the conduct of the affairs of the corporation.

As to Beer, Sondheimer & Co.—The business of Beer, Sondheimer & Co. is in process of liquidation. This includes not only the corporation Beer, Sondheimer & Co., Inc., but also its subsidiaries, the National Zinc Co., the Norfolk Smelting Co., and the Cuba Copper Leasing Co. It includes also the 100,000 shares of the stock of Minerals Separation North American Corporation out of a total issue of 500,000 shares. This stock will be disposed of by the custodian and will go into American hands.

As to Vogelstein & Co.—As in the case of Beer, Sondheimer & Co., when the custodian took over the business of L. Vogelstein & Co., Inc., he placed in control thereof a board of directors designated by him. Subsequent investigation by the custodian disclosed that Vogelstein, who was a naturalized American citizen, had a preponderating interest in the assets of the corporation, and inasmuch as it has as yet been impossible to obtain from Aron Hirsch & Sohn an accounting so as to determine that concern's exact interest in the assets of L. Vogelstein & Co., Inc., an arrangement has been perfected between the custodian and Vogelstein whereby all of the stock of the corporation has been put into a voting trust for a period of five years, the custodian naming two of the three voting trustees. Thus the control of the corporation for the next five years will be in the hands of trustees appointed by the alien property custodian. Vogelstein has agreed not to resume his relations with the Germans during this period of five years and to conduct the business of the corporation as a purely American concern. Vogelstein has agreed to pay to the custodian $1,668,671.49, being the amount of the apparent indebtedness from him to the Hirsches as of April 30, 1916, and has agreed to pay to the custodian all additional moneys that may be found to be due to the Hirsches upon a final accounting which is to be had within six months after the declaration of peace. Thus circumscribed and guarded, the control of the business has been turned back to Vogelstein, the custodian retaining two out of the five places on the board of directors as long as the custodian may have any interest in the business.

Stock Put in a Voting Trust

As to American Metal Co.—Soon after the trading-with-the-enemy act became a law, the Americans in control of the American Metal Co. not only promptly filed the report required by the act and disclosed therein the German ownership of about 49 per cent of the stock of the company, but offered to co-operate with the custodian in any direction looking to the elimination of the German interests. An investigation of the affairs of the company was courted and at the instance of the War Trade Board such an investigation was made and subsequently the alien property custodian likewise made an investigation of his own. The officers of the company heartily co-operated with the alien property custodian, which resulted in the first instance in the transfer to the custodian of the stock belonging to the Germans. The custodian was satisfied with the good faith of the management of the corporation and therefore designated but five out of the 15 directors of the company.

By agreement between the alien property custodian and the American stockholders, together controlling 53,264 shares (out of 70,000 shares outstanding) all of said stock has been placed in a voting trust for a period of five years. The alien property custodian is entitled to receive voting trust certificates representing the 34,644 shares of stock formerly held by enemy aliens. It is his purpose to offer these certificates for sale to the American public at public auction.

The policy of the alien property custodian to sell only to Americans will be strictly adhered to in this instance, and none of the voting trust certificates will be permitted to go into any but American ownership. The immediate result is that 76 per cent of the stock of the company will be owned by American citizens. The alien property custodian is in correspondence with the British authorities with a view to the deposit under the voting-trust agreement of the 16,736 shares held by Henry R. Merton & Co. and its allied interests. It is hoped that such action will be taken in the near future. When this has been done, the alien property custodian believes that all German ownership and influence will be effectually eliminated from the company.

Supreme Court Hears Minerals Separation vs. Butte & Superior

THE argument before the U. S. Supreme Court in the Minerals Separation vs. Butte & Superior infringement suit was heard on Wednesday, March 19. No extension of time was requested, as in the Hyde case, and there were no experimental demonstrations, as in that case. The plaintiff, Minerals Separation, divided its time into an opening and a closing, half an hour each; defendant, Butte & Superior, having the intervening hour.

In opening, counsel for Minerals Separation explained to the court that in the Hyde case the question before the Supreme Court had been as to the validity of the patent (835,120), the acts of infringement in that case having been clear. In the instant case, however, the Supreme Court having established the validity of the patent, the question before the court is as to the infringing nature of the defendant, who, previous to the Supreme Court decision, had been using about two-tenths of 1 per cent of pine oil, alone, as the flotation agent, but who immediately upon the Supreme Court's finding in favor of the validity of the patent, had, while continuing the use of the pine oil, to very little more than two-tenths previously used, added thereto eight-tenths of 1 per cent of petroleum oils, which the District Court, after a lengthy hearing, had found to be utterly useless as a frothing agent, and as the defendant had admitted was a wasteful use of oil.

Several of the Justices questioned counsel as to the limiting amount of the process, recalling to mind the colloquy which had taken place in the Hyde case, which colloquy was so prominently set forth in the opinion of the Court of Appeals in the present case. Counsel claimed that in that case counsel for plaintiff had been speaking of the use of oleic acid upon Broken Hill ore, and that the patent explained that for different ores and different oils, different proportions were required, and that the proper proportions in each case could only be ascertained by experiment. In argument, and in response to inquiry from the Justices, counsel for Minerals Separation insisted that these petroleum oils were absolutely useless as frothing agents and even actually harmful, so that the pine oil, which had previously done the work and was still doing the work, had to be slightly increased.

Counsel for the defendant, Butte & Superior, in opening stated that he came before the court with no intention whatever of questioning the court's decision in its sustaining the validity of this patent. He was anxious, he said, to assist the court in interpreting its decision, and with this end in view would recall the subject as it was presented to the court, going quite fully into the emphasis which had, in the Hyde case, been placed upon the "critical" proportions of oil, the minute, microscopic quantities, and showed that plaintiff's experts, as well as the patent itself, confined the process to these minute quantities; the plaintiff's own witnesses having testified that for all ores and all oils the world over, the proportions varied between 0.05 and 0.2 per cent. The colloquy of the Hyde case was also quite fully quoted.

The counsel for the defendant then took up the question as to the use of petroleum oil in flotation practice, showing the very general use of just such mixtures as defendant is now using, of mixtures of vegetable and mineral oils, and in the same relative proportions, by the licensees of Minerals Separation. He also quoted from the testimony of complainant's own witnesses as to the beneficial use of petroleum oils, and quoted the original English patent in which oleic acid and petrol are always specified together as absolutely equivalent. The first written report of the discovery also was quoted as showing the fact that petroleum oils were suitable oils.

The question as to the delay in filing a proper disclaimer of the three "small quantity" of oil claims was then taken up by counsel for defendant, who claimed that the disclaimer as filed was in fact no disclaimer whatever, but actually broadened the three claims in question by a tricky use of the wording of the Supreme Court decision in the Hyde case, in which the Supreme Court said: "The patent must be confined to the results obtained by the use of oil within the proportions often described as in the testimony and in the claims of the patent as 'critical proportions.'"

In the disclaimer they so repeated the words, "results obtained," as to make the disclaimer read that these claims are limited to a process in which the "results obtained are the results obtained by the use of" the critical proportions of oil. From this counsel argued that according to the statutes covering the question of disclaimer, the plaintiff, having up to this time in fact made no disclaimer, has no right to maintain a suit upon this patent.

In closing argument, counsel for plaintiff urged strongly the position that the use of petroleum in such manner did not conform to the prior art, as prior art was classified by the Supreme Court decision in the Hyde case. Oils, it was argued, have other necessary qualities than the "preferential affinity" referred to, as for example in Cuttermole process the additional property of forming granules. In this case the frothing quality was lacking for defendant's ore, citing an experiment before the District Court and claiming that defendant had never in its practice used petroleum oil alone. The gist of the Minerals Separation argument was that, when an oil will not effectuate, the process of the patent in suit, it is not an oil of the process. That appears to be that for one ore petroleum may be an oil of the process, while for another ore it may not be an oil of the process.

As to the disclaimer, the counsel for the plaintiff said that the "small quantity" claims 9, 10 and 11 were of a group different from all the other claims of the patent in that they were not limited, as the other claims of the patent, to a process which is obtained as the result of a froth formed by oil-coated mineral matters.

Arguments upon both sides were very able, and while one may question the advisability of attempting, in so limited a time, to cover so wide a subject as this case presents, it is perfectly clear that it was not possible even to touch upon many of its important features. The Justices were most attentive, showing an unusually keen interest from the very first word to the end of the arguments.

Civil Service Examinations

The United States Civil Service Commission announces open competitive examinations for junior metallurgist and junior mining engineer, for men only, April 15, 1919. Entrance salary, $1200 to $1500 a year. There are vacancies at Seattle, Wash., and Pittsburgh, Pa.

New General Import License

The necessity of obtaining individual licenses for the importation of unrestricted commodities from the United Kingdom, France, Italy or Belgium, or any of their possessions, may be avoided by using the general import license PBF 34, issued by the War Trade Board on March 6.

The following restricted commodities are expressly excluded from the terms of this license: Pig tin, tin ore, tin concentrates, all metal alloys containing more than 20 per cent tin, spiegeleisen, ferromanganese, emery, except that produced in Canada; salvarsan, neosalvarsan, arsephenamine, and all substitutes therefor and equivalents thereof; nitrate of soda, sugar.

Manganese and Chromium in California

Owing to the increased interest in manganese and chromium during the period of the war, all known deposits in California were visited and examined by members of the field staff of the State Mining Bureau. The results of these investigations are embodied in Bulletin No. 76, which may be obtained for 50c. postpaid, from the State Mining Bureau, Ferry Building, San Francisco.

As this is the only recent publication giving detailed data on the manganese and chromium resources of the entire State, it is still of value, in spite of the fact that the situation which led to the investigations no longer exists.

Waste Paper-Mill Bark as a Source of Tannin

The feasibility of using waste hemlock bark from paper-mill operations for tanning purposes has been further demonstrated in recent tests made by the Forest Products Laboratory. Results obtained first in an experimental way were so encouraging that the investigation was finally carried out on a semi-commercial scale in co-operation with a paper mill, a tannery and a manufacturer of drying equipment.

The conclusions reached are : (1) no great technical difficulties stand in the way of utilizing paper-mill bark for such purposes; (2) the product is satisfactory from the tanner's standpoint; (3) it can be prepared at a cost which will allow it to compete with leaf bark.

The use of paper-mill bark for tannin would mean a source of income for the paper mill from a material which is now of little or no value. In many cases it would also be the solution of a serious problem of stream pollution. The tanner would be assured of a constant supply of dried bark which would allow him to keep much less material in stock, to reduce his fire hazard and to wipe out the depreciation and interest charges which must be carried against a yard full of leaf bark. The lumberman would avoid increasing difficulties of obtaining satisfactory labor for bark peeling and would do away with the fire hazard and expense incidental to the peeling and seasoning operations, all of which combine to make the production of leaf bark an unsatisfactory business, even at the present market price.

It is believed, therefore, that utilization of waste paper-mill bark for tannin is a conservation measure which from every standpoint is worthy of being put into immediate practice.

Exhibit on Method of Classification of Personnel

Employers and others interested in personnel work will have an opportunity to examine the methods developed by the Committee on Classification of Personnel in the Army at an exhibit to be shown on the third floor of the Engineering Societies Building, 29 West 39th Street, New York City, April 1 to 12. The exhibit consists of a collection of wall charts, forms, photographs and models showing how the Army finds out what men can do best and how it uses that information; how soldiers are trade-tested, and how officers are rated and fitted into place; how the work is checked and supervised, and its results in the war. The collection is being shown under the auspices of the National Association of Corporation Schools and the United Engineering Society.

Opportunities for Disabled Men

The Federal Board for Vocational Education has suggested the positions of safety engineer and safety inspector as being suitable for men who have lost one eye or one arm but who still retain fair hearing and the use of both legs. Opportunities for work are numerous, as insurance companies, large industrial concerns, the Interstate Commerce Commission and various State and municipal departments offer good positions of this sort. The salary of the safety inspector will range from $1200 to $2000 a year and the course of training should be not less than three months, while those wishing to qualify as safety engineers, with a salary range from $1800 to $3000 per year, should continue their studies for at least six months.

Surplus Acid in the War Department

The Director of Sales, War Department, states that approximate quantities of surplus acid held by the Department on March 13 were as follows:

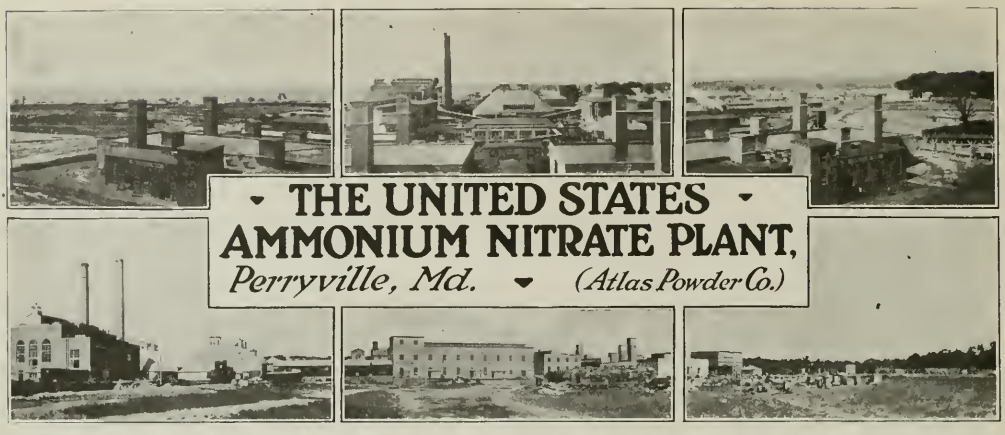
Sulphuric acid	4400 tons
Oleum	300 tons
Nitric acid	1000 tons
Mixed acid	2600 tons
Spent acid	700 tons

These quantities are very small compared with the total production and consumption of the country, nevertheless the Government will not dispose of it in such a way as to affect the market seriously.

Expansion of Japan's Trade During the War

A detailed trade study of Japan for the years 1913 to 1917 just issued by the United States Tariff Commission indicates striking changes in the commerce, industry and financial position of that country during the war period. Japan's total trade rose from $680,500,000 in 1913, to $1,319,000,000 in 1917, an increase of 94 per cent.

A special section of the report is devoted to the trade between Japan and the United States, from which it appears that at present the United States supplies a little over one-third of Japanese imports and takes nearly 30 per cent of Japan's exports. The sales to Japan consist mainly of ginned cotton, iron and steel, construction materials, machines and engines, and petroleum, while the purchases from Japan are made up principally of raw silk, silk tissues, tea, hemp and straw braids for making hats, champhor, beans and peas, porcelain, starch, buttons, surgical instruments and matches.



A Description of the Manufacture of Ammonium Nitrate by the Double Decomposition of Chilean Saltpeter and Ammonium Sulphate—Phases, Their Control and Application—Plant Operations

UP TO the present there have been military reasons for close secrecy about the Government ammonium nitrate plant at Perryville, Md., which was speedily constructed last spring. It was put into operation on July 20, replacing in about 100 days, with an enormous plant built of concrete, tile and steel, the green fields of a plantation famed since Colonial days for its fine view of the wide waters to the south, where Chesapeake Bay suddenly tapers into the gigantic Susquehanna River. The site was chosen because it offered most ample facilities for receiving great quantities of raw materials such as Chilean saltpeter at port, sulphate of ammonia from the coke-oven region by rail through the uncongested Susquehanna Valley route of the Pennsylvania R.R., coal and abundance of fresh water. Oil of vitriol, the so-called universal chemical manufacturing reagent, has not been listed, because no such intermediary is required for performing the direct cyclic process used in this operation and which was devised by Freeth and Cocksedge,[1] so that the following simple equilibrium is forced to the right, giving sufficiently pure needle ammonium nitrate by the double decomposition of the reciprocal salt-pairs. The common ammonium and nitrate salts of commerce are utilized without making any intermediates such as nitric acid or ammonium hydroxide.

$$2NaNO_3 + (NH_4)_2SO_4 \rightleftarrows Na_2SO_4 + 2NH_4NO_3.$$

Another process[2] somewhat similar has been described as operated in France, making use of the Solvay ammonium chloride liquor obtained from the familiar salt-ammonia-carbonate process for making sodium bicarbonate according to the reactions:

$$NaCl + NH_4OH + CO_2 \rightleftarrows NaHCO_3 + NH_4Cl,$$
$$NH_4Cl + NaNO_3 \rightleftarrows NaCl + NH_4NO_3.$$

[1]U. S. Pat. 1,051,097—1913. British Pats. 16,454—1910; 12,401—1915.

[2]Etude d'une Double Decomposition Saline Reversible. Par E. Rengade. Revue général des Sciences pures et appliquées. No. 17-18, Page 489-503, Sept. 1917.

The Germans are reported to have substituted the sodium chloride in the Solvay reaction with sodium nitrate and obtained ammonium nitrate liquor[3] directly, but this process could not have become of great importance with them, because of their shortage of crude Chilean nitrate salts. It was thought that the cost of carbon dioxide and lime, together with the manufacture of the accompanying complicated equipment necessary for the performance of the process, rendered this reaction of little use in such an emergency as existed during the days when the U. S. Ordnance Department had to create a munition industry with the greatest speed possible. Furthermore, the bicarbonate crystallized out is contaminated with several other salts and cannot be marketed directly as obtained.

The solubility curves in Fig. 1 indicate the ratio of each of the four salts involved in the equilibrium to 100 parts of water in single solution from 0 to 100 deg. C. In the case of the mixed-salts solutions, the saturation solubilities fall below the respective single solute curves in accordance with the law of the solubility-products of the constituent ions: NH_4, Na, NO_3 and SO_4. Groups 0 and 3 are examples of saturated concentrations which clearly indicate the depression of the ions by the drop in the points 0 and 3, (—, b and c) below the respective curves, Fig. 1, in the NH_4NO_3 — $NaNO_3$ — Na_2SO_4 salt system as actually used in the cycle operation of the sulphate-nitrate process of Freeth and Cocksedge. Besides the three well-known anhydrous, hepta- and deca-hydrous phases of sodium sulphate and the five enantiotropic crystalline phases of ammonium nitrate, the following four double salts exist to complicate matters and give impure yields:

$$Na_2SO_4 \cdot NaNO_3 \cdot H_2O,$$
$$Na_2SO_4 \cdot (NH_4)_2SO_4 \cdot 4H_2O,$$
$$(NH_4)_2SO_4 \cdot 2NH_4NO_3,$$
$$(NH_4)_2SO_4 \cdot 3NH_4NO_3.$$

[3]Thomas Fairley D. R. Pat. 97,400.

WASTE SULPHATE CONVEYOR WITH TRUCK LOADING ARRANGEMENTS

In the absence of a temperature-concentration chart showing the stability areas and equilibrium loci of this very complicated polyphase system only a brief account of the five forms of ammonium nitrate and their application in the manufacture of the explosive trinitrotoluene mixture called amatol will be given. A description of the plant equipment and operation will follow. The feature of the plant, the control of the temperature of the crystallizing liquors, will be completely treated in a separate article in a following issue.

Phases of Ammonium Nitrate

The four transition points of the five crystalline phases of ammonium nitrate are at —16, 32, 84 and 125 deg. C. The form existing below —16 deg. C. has no practical application and need not be described in this paper. The needle crystalline form, scientifically named beta-rhombic, is the usual and important salt, being stable from —16 to 32 deg. C. Its density as determined by flotation is 1.725 at 25 deg. C. Needle crystals have the exclusive commercial advantage of not caking into hard masses when stored and can be conveniently handled when the salt has not been allowed to become saturated with hygroscopic moisture. When heated through 33 deg. C., beta-rhombic crystals are immediately converted into alpha-rhombic crystals, a pseudomorph, that is, an aggregate of fine crystal particles of a new individual form but which retain the general external facial appearance of the original needle crystals. If the needles are stirred during heating, they break down into a very fine powder and when stored in the presence of moisture, harden together into a white opaque stone-like mass. The change in form is accompanied by about 3 per cent expansion, the density of the alpha crystals being 1.66. If a block of needle ammonium nitrate is heated and cooled through the transition temperatures (33-31 deg. C.), the permanent expansion sets up voids so that the block becomes spongy. After repeated heating and cooling the block will disintegrate. Because of the tendency to cake into a hardened mass in the presence of moisture, alpha-rhombic crystals are an undesirable commercial form. When a large amount of alpha crystals are allowed to cool, the temperature can be observed to stand at 31 deg. C. for a considerable period. The latent heat of the change from alpha- to beta-rhombic crystals has been determined to be 5 calories per gram, which is a considerable heat quantity in comparison to the low specific heat of such salts.

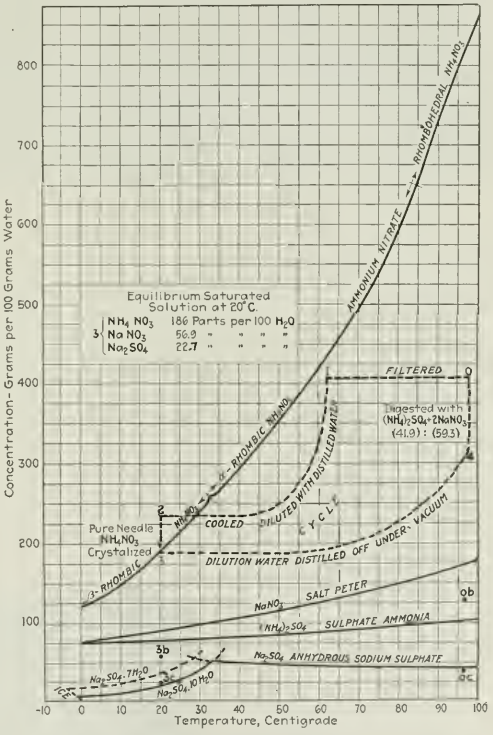
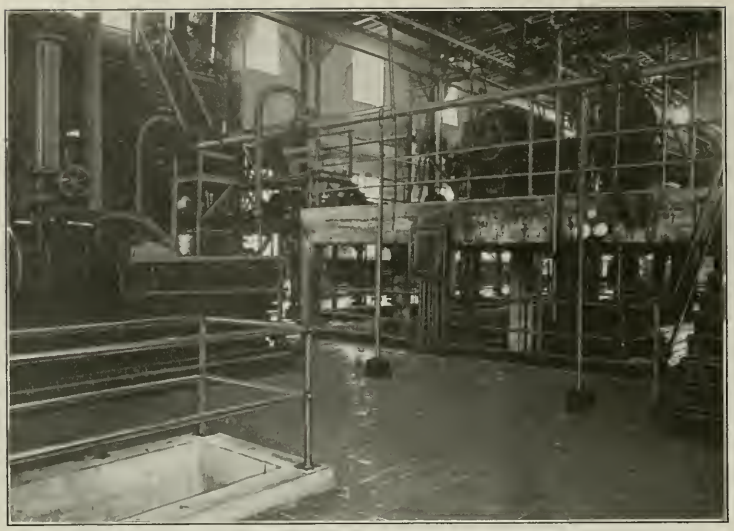


FIG. 1. SOLUBILITY CURVES AND PROCESS CYCLE

The transition to the rhombohedral form takes place at 84.2 deg. C. This change is abrupt, not showing a lag as in the previous case from 31 to 33 degrees; furthermore, the transition is not indicated by a distinct change in the solubility curve slope[4] as is shown at 32 degrees in the ammonium-nitrate curve of Fig. 1. When the salt is heated above its melting point, 169 deg. C., and cooled rapidly to atmospheric temperature, it passes directly to the needle phase showing no indication of the existence of or transition through the

CRUDE SALTS UNLOADING SHED AND STORAGE HOUSES

[4] W. Müller and P. Kaufmann, Zeitschr. physikal. Chem. 42,497. 1903.

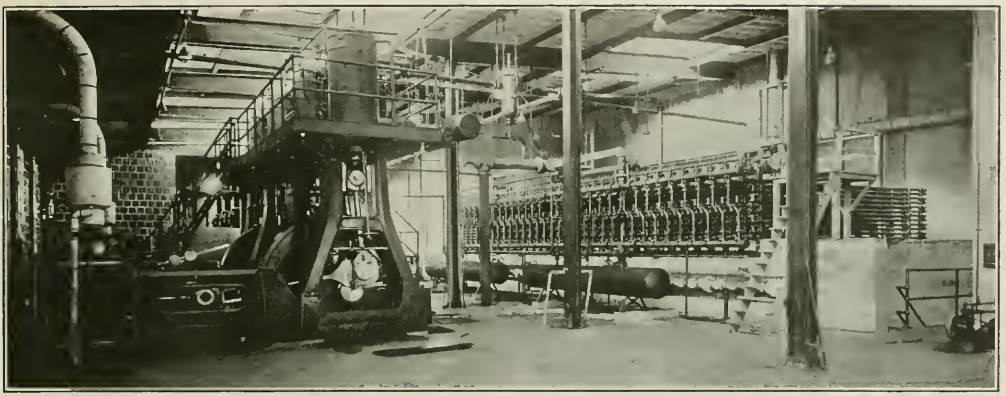


VACUUM FILTRATION DEPARTMENT—ROTARY FILTERS ON PLATFORMS

intermediate phases. The transition at 84 deg. C. is accompanied by a slight contraction in volume and an absorption of heat, the density becoming 1.69 and the latent heat amounting to 5.33 calories per gram. The rhombohedral and alpha-rhombic states of ammonium nitrate with their accompanying physical properties are very important in the manufacture of the explosive amatol (80 per cent NH_4NO_3, 20 per cent TNT). The latent heat of 4-grams of ammonium nitrate is 21.53, while the latent heat of fusion of trinitrotoluene is slightly less, 21.4 calories. Direct application is found for these balanced latent heats in shell loading, the amatol being heated to above 84 deg. C., and because of its reserve in latent heat of transition the temperature of the mass does not cool to below 84 deg. and during the lag period of transition the amatol remains in a plastic condition[5] long enough to be loaded into the shell. The fine powdery alpha phase prevents segregation and assures a disseminated and thorough mix with the trinitrotoluol, producing a homogeneous amatol. When heated through 125 deg. C. the cubic system appears, the fine particles of which cling together in an almost collodial glue-like mass. This phase is one to be strictly avoided in ammunition work and prohibits the use of steam coils in contact with the salt. One per cent of water will lower the melting point of the salt from 169 to 159 deg. C., while 20 per cent of sodium nitrate with the salt gives a product melting at 120 deg. C. Thus it will be seen that in the presence of these materials, low temperature molten salts fusions are characteristic. Ammonium sulphate usually contains fixed coal-tar bases such as pyridene as well as from 1 to ½ per cent free sulphuric acid. The organic base is an undesirable impurity in amatol and the acid augments the very corrosive action of the concentrated nitrate salts on the equipment. Therefore sufficient soda ash to give a slight alkaline reaction is added so that both the pyridene is free to be volatized during the heating in the digestors and the liquor has as weak an acidic action as is possible with such a weak base as ammonium. No average analysis of Chilean saltpeter can represent the commercial conditions found in practice, for the caliche beds vary among themselves considerably as well as the methods of leaching them and crystallizing the more or less refined salts. The principal sodium salt impurities are chlorides, sulphates, borates and iodides. Potassium is the most important as well as variable foreign base present, good caliche earth often analyzing from 25 to 30 per cent $NaNO_3$ and from 3 to 5 and even 10 per cent KNO_3, with a result that extracted salts are found with minimums around 2 per cent KNO_3 and maximums up to 8. Ordinarily the percentage of sodium nitrate in Chilean saltpeter is in the lower nineties. Before the crude saltpeter can be used in the double decomposition process, it

DIGESTOR DEPARTMENT—BATTERY OF EIGHT 900-CU.FT. DISSOLVERS IN GRAVITY CIRCUIT

[5]Melting points TNT, 2:4:6, 80.8°C; 2:3:4, 112°C; 2:4:5, 104°C.



CARRIER AIR CONDITIONING DEPARTMENT—COMPRESSORS AND COOLERS

must be thoroughly refined so as to prevent as far as possible the accumulation of foreign salts in the nucleus solution and especially remove the potassium salts, which have the property of crystallizing out with the needle ammonium nitrate, forming a highly undesirable impurity in amatol. Any alkaline earths that may be present will be precipitated as carbonates by the initial addition of soda ash and will pass out of the nucleus solution at the filters with the anhydrous sodium sulphate precipitate and other foreign solids. The halogen impurities are of minor importance, and so do not seriously affect the reaction. Next to potassium, the most trouble was found in keeping the solution cleared from pieces of bags, cordage, etc., which clogged the pump inlets.

Organization of Plant

The Atlas Powder Co. acted as agent for the Ordnance Department and installed an experimental plant where the details regarding apparatus, capacities and design ratios for carrying out the process were determined as well as possible. This was of prime importance in securing and training an experienced staff during the period in which the plant was being constructed so that no time would be lost in starting the works as soon as completed.

The process was operated continuously in three 8-hour shifts. A total of one hundred executives and technical men and 1800 mechanics and laborers were required in the operation. Mr. Frank S. Pollock, plant manager, was in charge of manufacture and plant. Among the personnel, the following should be mentioned:

Major A. S. Sinclair, contracting officer, U. S. O. D.
Mr. E. E. Bard, assistant plant manager.
Mr. J. T. Power, in charge of construction.
Dr. Guy C. Given, chemical research.
Dr. Frederick Bonnet, chief chemist.

Power and Water Plant

The Fred T. Ley Co. of Springfield, Mass., built the entire plant and are to be commended for their speedy and excellent construction, especially of the twelve 830-hp. boiler power plant in the record breaking speed of 64 days. A 10,000-hp. B. & W. Stirling boiler installation equipped with Westinghouse electric stokers, 4500-ton capacity overhead coal bunkers, two 210-ft. hollow tile stacks, steel derricks with clamshell coal buckets and three 1000-kw. condensing turbo alternators, together with forty miles of steam and water pipe lines from 30-in. diameter down make a million-dollar job alone, and in ordinary times might be considered as a large undertaking. However, compared to the expenditures for the entire plant, the power department cost about 7 per cent.

Water was obtained from the Susquehanna River by a main pump house having a capacity of 30,000,000 gal. per 24 hours. A special sluiceway had to be sheet piled and excavated to deep water so as to obtain a clear flow to the pump. Ninety-five per cent of the water was used direct for cooling purposes in the plant and was exhausted into Chesapeake Bay through the sewerage system, while the remaining million gallons was refined by the usual alum filtration and liquid chlorine process and used in supplying the boilers and potable mains throughout the plant and village. About 80 per cent of the boiler steam was consumed directly in heating the digestors and evaporators and 10 per cent each in the water pumping station and in the electric power house, which supplied the lighting system and the motors throughout the plant used in driving pumps, agitators, belt and bucket conveyors, compressors, fans, rotary filters, etc.

Chemical Plant Layout

The chemical plant consists of two similar independent units of equal capacity, with the soda purification, distilled water and liquor storage, centrifugal and finished product houses in common. The solid materials were transported on belt conveyors through tunnels. Stationary and portable bucket conveyors were used for elevating the materials to the crude storage piles and charging the belts and weighing machines. The buildings were constructed of hollow tile and concrete so as to reduce fire risks and furnish heat insulation for the process. As ammonium nitrate has a disintegrating action on concrete, all floors likely to come in contact with this material are tiled, especially those in the liquor filtering and pumping departments. The buildings were roofed with 3-ply everlastic laid on a yellow pine deck attached to steel beams.

A standard gage railroad track makes a complete loop around the plant, double tracks passing on both sides of the raw material stores and under the finished product bins, allowing ample unloading and loading space, and, with the sidings, giving a 5½-mile yard within the works.

The production capacity of finished ammonium nitrate of 94 per cent purity and 2 per cent moisture content was close to 300 long tons per 24 hours. This required the handling of 350 tons of sodium nitrate, 300 tons ammonium sulphate and 4½ tons of soda ash per day.

Crude Storage Houses

As one enters the gates, the odd ten-sided structures conforming to the outlines of piled materials, with incline conveyors climbing up their pyramidal roofs, first excite one's curiosity. The two largest, with "Crude Soda" painted on their concrete walls between the bracings, hold around 1000 carloads of saltpeter when full. The smaller octagon-shaped stores marked "Sulphate" have much less capacity because ammonia is a domestic material and need not be carried in such large stocks. The storage spaces for soda ash and refined soda are also of modest size and for evident reasons, the latter being a governor on the soda refinery and carrying sufficient supplies to tide over minor interruptions in the previous operations.

The empty nitrate sacks are sent to the bag washing department, where they are mechanically freed from as much soda as possible in a tumbling reel and then conveyed counter-currently through a simple rectangular box washer, passed through a wringer and dried in a hurricane Philadelphia drying machine. The feed water is so adjusted as to furnish a saturated solution of nitrate which is piped to the saltpeter purification department storage liquor tank.

The crude sodium nitrate crystals were fed directly into a Dorr six-deck washing classifier set at a 2½-in. pitch, which agitated and conveyed the crystals up through the down-coming saturated nitrate solution from the bag washing department. A sufficient extraction of the potash and chloride content was obtained with the exhausted wash liquor carrying about 34 per cent $NaNO_3$ and 28 per cent KNO_3. While quite successful in the operation, two important difficulties were experienced, of which the accumulation of fines at the base of the classifier was very serious, overloading the mechanical parts of the machine and making it necessary to reinforce points that were over-stressed. This was counteracted by discharging the fines at the base at intervals. The other difficulty was to free the crystals from sufficient mother liquor to break their coherence. This was accomplished by riveting a three-foot apron of eighty-mesh punched sheet iron at the crystal discharge end and extending the rake sufficiently to convey the material over the screen. It was intended to apply suction and thus pull the adhering wash liquor off. An Oliver sand filter was used successfully during the operation of the plant for preparing the crystals for conveying to and storage in the "Pure Soda" building.

The wash liquor was concentrated in two large Buflovak vacuum evaporators and the several salts crystallized in fractions. This department was being developed by the research department and had not reached a permanent manufacturing basis, but undoubtedly pure potash salts would have ultimately been made on a large scale[6].

Digestion Departments

The two batteries of 900-cu.ft. Buflokast iron horizontal cylindrical digestors are housed in separate buildings between which the mother liquor storage tank house intervenes. Each battery was installed with eight digestors, the combined contents of which was 450 tons of solution per unit, the flow of which was obtained by an eighteen-inch drop in level between digestors. During the operation it was found that numbers five, six and seven could be dispensed with. The digestors were connected by both overflow open conductors and underfeed pipes. The materials were added continuously to number one at a normal rate of 500 pounds per minute through automatic weighing machines. The salts are thoroughly agitated with the hot nucleus solution. Steam is blown in directly to obtain rapid fusion. Samples are taken constantly and the end of the reaction is determined by the absence of sulphate in the sublimate obtained from volatilized ammonia salt vapors upon fusing the dehydrated liquor.

MOTHER LIQUOR CONCENTRATION DEPARTMENT NO. 1—VACUUM EVAPORATOR AND MIXING TANKS

[6]Process for Separating $NaNO_3$-KNO_3, Given and Barteaux, U. S. P. 1,294,788.

Great care must be taken in preventing the pipe lines from becoming frozen or blocked with solidified salts, and when a pump is stopped for repairs the line must be blown with air or steam immediately and flushed with hot water to remove any accumulated solid crusts. The greatest trouble experienced in the operation of the plant was with the pumping equipment. The hot concentrated nitrate salts probably enjoy the record for corrosive efficiency, often demonstrating this by putting a new pump out of business in a few hours of use. The pump packing found most successful was asbestos graphited braid which had been slightly lubricated with soap, which probably reacted with the liquor, giving a modification of the so-called nitrated-oil rubber. As more or less bagging, rags and rubbish seemed to get into the liquor in spite of many precautions, it was not thought safe to use silicon iron, which is very brittle and apt to break when jammed suddenly. However, a screen trap could have supplied a cure for this trouble and undoubtedly chemical iron ware would have been a boon to the pump man.

The liquor pumps did not enjoy a monopoly of the pump troubles, for the vacuum apparatus pulled a fine liquor spray into its headers which solidified and acted most effectively, making frequent clean-outs necessary which were humorously referred to by the men with some thought of their rival at Muscle Shoals as their "Air Nitrate Plant." This trouble was eventually overcome by greatly enlarging the size of the exhaust mains with a consequent decrease in the gas velocity to a point where no spray was carried to the cold zones.

The liquor was filtered with Oliver continuous vacuum rotary filters. Extra ports were added so as better to distribute the suction and clearing steam back pressure. Cotton, monel metal and wool fabric were used, the former being immediately destroyed, the second lasting about two weeks at a cost of $400 per filter and the third giving the cheapest service, lasting one week at a cost of $67 per machine. A quarter-inch mesh aluminium-wire screen was applied to the cylinder, the wool placed over it and wound spirally with heavy monel wire, six revolutions to the inch. Both the aluminium and monel metal had given permanent service without replacement. As about twenty Olivers were in operation, the filter fabric was an important cost. The support received by the wool determined its life, for as soon as bulges were formed between the monel spiral, the friction of the scraper soon wore a hole through the fabric and made its immediate removal necessary. The anhydrous sodium sulphate crystals removed from the filters were mixed with distilled water, refiltered and dumped to the waste belt conveyor. As the hydrous phases begin to form at temperatures below 33 deg. C., considerable trouble was experienced with rebuilding crystals, which grew tenaciously to the idler rolls, the belt and everything with which they came in contact, somewhat after the manner of freezing water. While the most excellent service was obtained from the nitrate, sulphate and carbonate conveyor systems in the other parts of the operation, dump cars or even hydraulic conveying perhaps would have been more suited to this department. At the end of November, the sulphate dump contained about five hundred carloads of salt, which carried a small content of nitrates. Among the illustrations a view is given of the waste conveyor and trestel incline, which is designed so that the salt coming from the main cross-tunnel belt conveyor serving the two digestor liquor filter departments could be either dumped into trucks or carried to the storage pile.

Upon consulting the cycle graphically charted in Fig. 1, it will be seen that the filtrate, if simply cooled to 20 deg. C., would be supersaturated with all three salts. In European practice, several methods of separation have been worked. Roth[7] claims to get good yields by fractional fusions of the anhydrous salts. Lennox[8] sublimates under vacuum and Craig[9] carries over the ammonium nitrate vapor with ammonium gas. As there is a wide variation in solubilities, fractional crystallization commends itself. However, where efficient vacuum evaporating apparatus is used, the best method of refining is believed to be had by simply adding sufficient water to the liquor to bring the sodium nitrate down to 3b and the sulphate to 3c as shown in Fig. 1. The cycle shown illustrates the character of the process outlined, but does not represent the actual practice. Since

[7]D. R. Pat. 48,705, 53,364 and 55,155.
[8]D. R. Pat. 96,689.
[9]D. R. Pat. 92,172.

CRYSTAL DRYING DEPARTMENT—FOUR BATTERIES OF TOLHURST CENTRIFUGALS

the initial hydration of anhydrous sodium sulphate produces the heptahydrate[10] the point 3c will be located between the hepta and deca curves. However, dilution is always based on the ordinate 3b — 0b, since the sodium nitrate solubility increases with higher temperature and the sulphate decreases. The NO_3 ion of the very soluble ammonium nitrate depresses the solubility of the saltpeter to 0b, while the Na ion of the nitrate depresses the sulphate down to 0c. In determining the required amount of water for dilution, crystal tests were run for the sodium salts at the mixing tank, which were continuous, the ratio of the two liquid feeds being gaged by calibrated Pelton nozzle orifices.[11]

Crystallization Departments

The crystallizing building of each of the plant units was divided into four sections, each of which was equipped with fifteen rows of eight-deck 40-cu.ft. iron pans. As about 120 pans were filled per hour, all the parts took care of the production of an 8-hr. shift. In order to prevent the temperature from falling below 20 deg. C., where the sodium salts would be crystallized out, and yet obtain a maximum yield of ammonium nitrate needle crystals, it was necessary to install an air conditioning plant with each of the pan rooms. Four Carrier automatic temperature and humidity regulating systems were installed, where the crystallization was carried out under controlled conditions at 20 deg. C. Full treatment will be given to this operation in an early issue.

When the ammonium nitrate content of the mother liquor in the crystal pans is sufficiently low, the plug is pulled and the liquor allowed to drain off into a pipe line leading to the mother liquor storage building, located between the digestor buildings, where it is pumped into one of the sixteen 3000-cu.ft. tanks located there. Three 900-cu.ft. Buflovak vacuum evaporators are in each digestor building, by which the spent mother liquor is concentrated to nucleus liquor concentration to be returned to the next cycle. At the same time, the condensed vapors furnish distilled water for subsequent diluting and washing.

The drained crystals are raked from the pans to a belt conveyor, which charges them into Tolhurst centrifugals. The moisture content is quickly reduced to the 3 per cent maximum and the finished product discharged from the bottom to a belt conveyor, which carries it to elevated storage bins to be loaded into box cars by gravity upon shipment. Thirty-two centrifugals are used, eight to the crystallizing room, or one to each fifteen pans.

Due to the sudden cessation of the manufacture of explosives, this plant was closed after almost as brief an operating period as it took to construct it. However, it met in excess all the demands made upon it and is a far better investment than commonly can be made by the War Department. It cost less than half the usual expenditure for a battleship and is capable of abundantly rendering more than its equitable share in the national business of war. Furthermore, should war go out of style, this plant can be readily converted to peace-time pursuits.

[10]Loewel, Ann. Chem. Phys. 49, p. 50, 1875.
[11]The formula is: $Q = 99d^{1.93}H$, Q = quantity lb., d = diameter orifice, H = heat in feet

Reclaiming Steel Works and Industrial Wastes

By Francis Hall

FUNDAMENTALLY wastes may be divided into two classes—waste of materials and waste of effort. In what follows, material wastes only are to be treated.

The principle of saving of wastes is almost as old as the hills. It was dwelt upon at length in the Holy Scriptures and was practiced in ancient times. No doubt, owing to the greater simplicity of life and industry in earlier times, more stress was laid upon savings and the control of wastes was easier. In any event, the salvage and control of wastes are anything but a simple matter at present, whether they be household, governmental or industrial.

As the volume of business and the magnitude of individual undertakings have increased, the facilities and the means of every kind have increased in size and complexity. Higher grade products and higher efficiency of production have frequently increased rather than lessened the amount of material classified as primary wastes. At all times, in America particularly, the general slogan has been "production," "get out the product." With works' executives, superintendents, foremen and leaders all constantly absorbed in getting greater production, it is not strange that the humble but highly profitable task of utilizing any accruing wastes to the same degree of efficiency should be neglected.

Importance of Saving in Peace Time

Fundamentally, America is not a saving country. As practiced by the French, saving and reclaiming almost every available bit of waste, as well as money, are generally unknown here. If saving is important in war times as a national necessity, it is doubly important in peace in order to preserve the national ease, comfort and standard of living at times when the lowest-priced good products command the market. In steel, munition, engineering, chemical, mining, and in general in all other industries, the fundamental ability of a plant to get the most out of its materials is largely dependent upon a personal equation—not of its executives, but of its workmen, down to the lowest rank. Most executives realize this, but somehow it has seemed difficult to compass effective salvage of materials when men and leaders devote unstintedly their time and effort to attaining a splendid volume of production. Moreover, neither the executive, foremen nor workmen have, as a rule, any clear personal idea of what it means to save their own, much less save somebody else's (their employer's) waste material. It is all waste or junk to them, fit for the dump or ash heap and therefore not worth bothering their heads about, so long as it is gotten out of the way promptly.

Most Americans are familiar with the slogan of the great packing industry, who claim to be saving and utilizing the entire pig, beyond the squeal. This seems literally true, and in fact is forcibly brought out by the recently issued report of one of the large packing concerns showing their entire yearly profit to have been made by utilizing to the last degree the by-products formerly wasted.

It is unfortunate that the same may not be said of the majority of other American industries. The surest sign of the lack of waste-salvage is the scrap pile, and this applies, paradoxically though it may seem, to the steel industry. For while scrap enters largely into the manufacture of steel, the character and makeup of the scrap stock-piles of a steel plant provide a sure indication of the degree of wastage occurring in the department or outside industry where it originated.

The most complicated problem of salvage so far undertaken is presented by the modern fully-integrated steel works with production from mine and scrap to finished product, be it principally armor plate, armor piercing projectile, shrapnel, high powered ordnance, turbine elements, car wheels, forgings, shafting, sheet, ships, bars, plates, rolls—all finished or green materials. Why this is true may be easily explained when it is understood that the large combined steel and ordnance works require nearly every branch of modern engineering and technical skill, together with the accompanying vast flow of both raw and finished material and innumerable kinds and classes of standard and special equipment and tools. In addition to the primary or producing departments, such as blast furnace, open-hearth, blooming mills, rolling mills, bar mills, sheet mills, rail mills, tire mills, steel foundry, forge shops, press plants, annealing plants, oil tempering plant, armor tempering plant, projectile plant and ordnance plant, consider that there may be necessary from 30 to 75 separate and distinct auxiliary departmental organizations, each demanding a constant flow of more or less specialized material and equipment and a consequently inevitable outgo of used, partly used, good, new, worthless and indifferent scrap, waste material and equipment.

Money in the Junk Pile

Consider this and the multitude of real facts about such a plant one can find by tedious, persevering and painstaking watchfulness and personal investigation, and the most recalcitrant doubter will become convinced that there must be something in that specialized industry that maintains and waxes rich a junk man in every little town. He will find that rubber is rubber, burlap is burlap, leather is leather, and lumber, asbestos, pipe fittings, electrical parts, pulleys, blanks, gears, bushings and so on almost to infinity are each what they are —scrap, good or fair, and each item capable of yielding dollars like finding the money by a simple common-sense treatment. He will also realize that by reducing the handling of current waste material by regularly and systematically collecting, disposing and utilizing it at some other place in the works as far as possible he can cut his costs of operation to where a low-priced contract can be taken now and then that will "keep the wheels rolling." He will find that those short (but otherwise good) bars, tubes, plates, rolls, castings, forgings, ingots, tool steel or merchant bar are just what some engineering, shipbuilding, railroad, electrical or machine works may be dying to get and would pay a round price for—a price that will make melting-up and thereby destroying the real value look more than criminal, besides adding a nice fat look to the profit side of the balance sheet.

He will, at length, learn the simple maxim that "a penny saved is a penny earned" just the same in a steel plant or aircraft or metallurgical works as in his own personal affairs.

It is not only patriotic, it is common sense, to save and utilize, to reclaim all available material of every kind, to dispose of it regularly and profitably, to eliminate entirely in America for all time the costly hideous miscellaneous scrap piles. It is the highest type of war preparedness or industrial peace preparedness that spells the real quality of invincibility. In extenuation of the lamentable condition as to nation-wide wastes in which the United States has by this war discovered herself may be advanced the freedom from real want and the universal easy-living conditions so long continued as to dull the usual sense of caution.

It may be safely said that no modern specialist is required to be as versatile and widely technically informed as in the new vocation of industrial reclamation engineering. Initiative, imagination, decision, resource and ingenuity must be available to the last degree in making the big and profitable undertaking such work will become in almost any American works. The general principles involved in the handling of scrap and wastes profitably on a large scale and in the variety found in a large steel or industrial plant are simple enough. Getting the business going promptly and in a way to pay for itself from the start is a task which will take all any normal being has in him.

Philadelphia, Penn.

Commission to Settle Losses on War Minerals

Former Senator J. F. Shafroth of Colorado, Philip N. Moore of St. Louis, Mo., and former Representative M. D. Foster of Illinois have been appointed by Secretary of the Interior Lane as members of the commission that will have charge of the payment of the losses incurred by mining men in the production of manganese, chrome, pyrites and tungsten for war purposes.

During the war the Interior Department, the Emergency Fleet Corporation and the War Industries, War Trade and Shipping Boards insistently urged the mining men to produce these materials to supply the urgent needs of the nation for war purposes. When the armistice came, these mineral producers, as a result of their response to the demands of the Government, had on hand ready for delivery quantities of these materials, for which there was no peace-time market.

Congress set aside $8,500,000 to meet claims for these losses, which must be filed within three months after the passage of the act. The law provides that the claims must have been incurred between April 6, 1917, when the United States went to war, and Nov. 12, 1918, when the armistice was signed. The Secretary of the Interior is charged in the act with taking into consideration and charging to the claimant the market value of the minerals on hand Nov. 12, 1918, and also the salvage or usable value of the machinery that was installed to produce these war minerals.

Mr. Moore is a former president of the American Institute of Mining Engineers and a well known engineer.

Mr. Shafroth was a member of the Senate Committee on Mines and Mining of the Sixty-fifth Congress and Mr. Foster was chairman of the House Committee on Mines and Mining.

Practical Considerations in Ammonia Leaching of Copper-Bearing Ores

Description of Plant Installation and Operation—Leaching Tanks: Plate Joinings, Filters and Inlets—Piping and Pumps—Evaporators—Details of Operation: Charging and Extracting Ore, Chemical Control—Cost of Leaching: Labor, Power and Ammonia

By LAWRENCE EDDY
Formerly Mill Superintendent, Kennecott Copper Corp., Kennecott, Alaska

THE engineering profession is already acquainted with the successful extraction of copper from its ores by an ammoniacal solution. In the year just past a number of improvements, mostly of a mechanical nature, have been worked out at the plant of the Kennecott Copper Corporation at Kennecott, Alaska. These developments are presented here, with some other points of interest to practical metallurgists.

The leaching plant at Kennecott is designed to treat the tailings from a "wet" concentrating mill, and has handled 450 tons of mill tailings per 24 hours, average of one month's run. The maximum capacity, however, with the equipment as herein described, is over 600 tons per day. Scarcity of ammonia and other abnormal conditions have reduced the tonnage to the lower figure.

The ore as mined contains copper in the form of sulphides, mostly chalcocite with some covellite, and also oxidized copper in the form of the carbonate malachite. The gangue is limestone. There is no native copper metal present. Treatment of the ore on concentrating jigs and tables gives a very good recovery of the heavy sulphides, but the malachite is inclined to be porous and flaky, and is of nearly the same specific gravity as the limestone, hence 40 per cent of this copper escapes from the jigs into their tailings. The ordinary acid leach is not suitable to recover this copper because it also attacks the limestone. Flotation would entail more grinding and the dubious problem of sulphidizing.

Under these circumstances ammonia leaching was adopted, and the process has now been cheapened so as to permit its application to a wide range of ores. Ammonia will not recover any gold or silver values, or any copper sulphides unless roasting is resorted to. With oxidized copper having the general form $CuCO_3 \cdot Cu(OH)_2$ a dark blue solution is formed which on heating gives off NH_3 vapor, CO_2 gas, and deposits a heavy black powder consisting mostly of CuO. The writer is not prepared to give the chemical formula of the blue copper-ammonia solution; he believes it to be a mixture of cuprous and cupric combinations, and that the proportions differ under different conditions. Table I shows the character of the mill tailings as they reach the leaching plant. Copper sulphides are also present in addition to the oxidized minerals to the extent of 0.20 per cent, but, being inactive in the leach, they are considered as part of the gangue. Roasting would not pay as so small a quantity of sulphides would be recovered.

Brief Comment on Flow Diagram

Item 1. Mill tailings are leached just as they come from the jigs and tables without any further crushing. They must be deslimed, however, because the slimes have the bad effect of cementing the ore together in the leaching tanks, forming a hard mass that is not easily penetrated by the leaching solution or the steam wash. It is also much harder to excavate the leached tails unless they are cleaned of material finer than 200 mesh. Desliming apparatus consists of two esperanzas 5 ft. wide and 30 ft. long. One only is in use at a time, the other being a spare. Table II shows the character of the deslimed ore. Most of the minus 200 mesh material has been removed, but all the fine sands are left in the ore. At present these slimes are run to waste, pending further developments in a process for their treatment. An extraction of 80 per cent can be obtained from the deslimed ore. Screen tests show that the best results are had with finer sizes, plus 60 mesh material giving the best extraction. However, the recovery from the coarser sizes does not drop enough to warrant putting

TABLE I. SCREEN TEST OF MILL TAILINGS

Size	Per Cent Weight	Assay Per Cent Ox. Cu	Lb. Ox. Cu in 100 Lb. Ore	Ox. Cu Per Cent Distrib.
+ 12 mm.	5.6	0.69	0.0386	3.8
+ 9 mm.	17.0	0.71	0.1208	12.0
+ 6 mm.	24.5	0.75	0.1839	18.3
+ 2 mm.	27.6	0.79	0.2180	21.7
+ 1 mm.	5.6	0.90	0.0504	5.0
+ 40 mesh	4.1	1.20	0.0492	4.9
+ 60 mesh	1.9	1.43	0.0272	2.7
+100 mesh	2.7	1.41	0.0381	3.8
+150 mesh	1.3	1.20	0.0156	1.6
+200 mesh	1.5	1.45	0.0217	2.2
—200 mesh	8.2	2.94	0.2411	24.0
	100.0		1.0046	100.0

TABLE II. SCREEN TEST ON LEACHING PLANT HEADS

Size	Per Cent Weight	Assay Per Cent Ox. Cu	Lb. Ox. Cu in 100 Lb. Ore	Ox. Cu Per Cent Distrib.
+ 12 mm.	6.0	0.69	0.0414	4.7
+ 9 mm.	18.1	0.71	0.1286	14.7
+ 6 mm.	26.1	0.75	0.1959	22.4
+ 2 mm.	29.4	0.79	0.2321	26.5
+ 1 mm.	6.0	0.90	0.0540	6.2
+ 40 mesh	4.4	1.20	0.0528	6.0
+ 60 mesh	2.0	1.43	0.0286	3.3
+100 mesh	2.9	1.41	0.0408	4.7
+150 mesh	1.4	1.20	0.0168	1.9
+200 mesh	1.6	1.45	0.0232	2.6
—200 mesh	2.1	2.94	0.0617	7.0
	100.0		0.8759	100.0

TABLE III. SCREEN TEST OF LEACHING PLANT TAILINGS

Size	Per Cent Weight	Assay Per Cent Ox. Cu	Lb. Ox. Cu in 100 Lb. Ore	Ox. Cu Per Cent Distrib.
+ 12 mm.	6.0	0.21	0.0126	6.1
+ 9 mm.	18.1	0.18	0.0326	15.7
+ 6 mm.	26.1	0.18	0.0469	22.7
+ 2 mm.	29.4	0.19	0.0558	26.9
+ 1 mm.	6.0	0.19	0.0114	5.5
+ 40 mesh	4.4	0.25	0.0110	5.3
+ 60 mesh	2.0	0.28	0.0056	2.7
+100 mesh	2.9	0.28	0.0081	3.9
+150 mesh	1.4	0.29	0.0038	1.8
+200 mesh	1.6	0.32	0.0051	2.5
—200 mesh	2.1	0.68	0.0143	6.9
	100.0		0.2072	100.0

in a crushing plant, especially since it would entail a still greater slime loss.

Item 2. A 300-ton storage bin is installed to permit of short shut-downs in either mill or leaching plant without inconvenience to the other.

Item 3. The ore is fed from bin gate to an elevator by a 32-in. "apron" feeder; it is elevated to the top of leaching tanks and conveyed by a chain-scraper to the charging doors on the tops of the leaching tanks, into which it drops by gravity. The resulting cone of ore is leveled off inside the tanks by revolving the excavator mechanism backward, and by hand shoveling. Rate of charging tanks is about 600 tons per 24 hours.

Item 4. It is to be understood that processes 4 to 10 are applied to the ore without transferring it from one tank to another. The order in which each step of the process occurs is from top to bottom of the chart. There are eight steel leaching tanks constructed as shown in Fig. 2 which are charged and put through these proc-

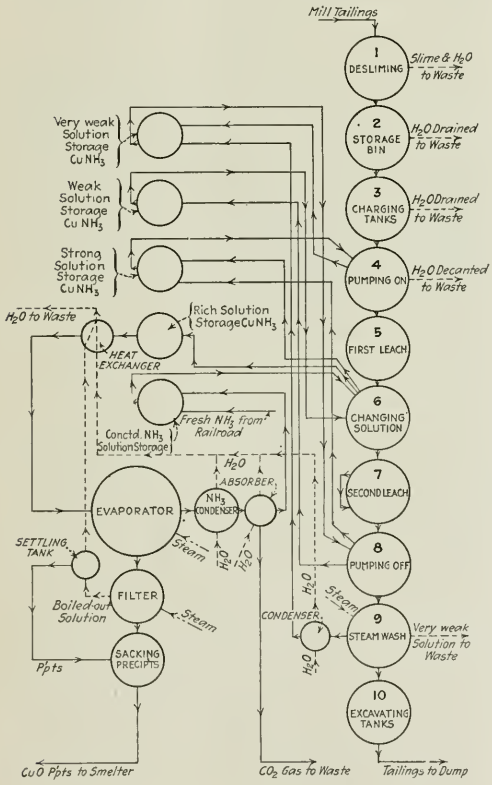


FIG. 1. FLOW DIAGRAM

esses in rotation. Process 4 requires about eight hours, during which the lixivant is pumped into the bottom of the tank and rises up through it. This displaces the moisture contained in the ore upward to the top of the tank, which is still approximately 5 per cent of the dry weight. Part of this can be decanted off the top of the charge to waste as it rises above the incoming ammonia solution, while part becomes mixed with ammonia and is decanted into the weak-solution tank. The remainder is left in the ore, where it dilutes the leaching solution.

Item 5. The ammonia solution is allowed to stand on the ore for 12 hours, without any agitation.

Item 6. A portion of the first leaching solution, approximately saturated with copper, is pumped from the bottom of the leaching tank; at the same time an equal volume of concentrated ammonia, together with some weak copper-ammonia solution, is pumped on the top of the charge.

Item 7. For 30 hours the leaching solution is circulated through the charge by a centrifugal pump which draws the solution from the bottom and discharges it on the top of the charge.

Item 8. Having dissolved all the copper that will go into solution in 30 hours, the leach is now drawn off from the bottom of the charge and transferred to the storage tank for strong copper-ammonia solution; at the same time 20 or 30 tons of weak solution or "wash" are pumped to the top of the charge and allowed to trickle down through it so as to wash out the strong leaching solution.

Item 9. Steam is turned into the top of the tank for about 12 hours, so that it heats the entire charge. This vaporizes any ammonia left in the ore, the weak ammonia vapor passing out of the tank through the drain pipes in the bottom and being recovered in a special condenser, from which it is transferred to the weak-solution storage tank. When the ammonia content of this condensate has fallen to 0.45 per cent, the wash is considered finished and the steam turned off.

Item 10. The doors in the bottom of the tank are opened, which allows the tailings to run out on a conveyor belt and thence to the tailings dump. Less than half of the charge runs out by gravity; the rest is excavated by means of a number of scrapers that revolve about a central shaft and are fed down through the tank by means of an automatic feed screw. Some of the tanks are not yet equipped with this excavating mechanism, and in them a light "slip scraper" is used, guided by hand and pulled by a small hoisting cable working through the top door of the tank. This device is unsatisfactory because a great deal of time and valuable cooling water must be expended before a man can get into the tank to guide the slip. Formerly all tanks were excavated by hand shoveling at a cost of about 11c. per ton.

The Leaching Tanks

More particular comment will now be made on the special appliances used. Fig. 2 is a sectional view of one of the leaching tanks, of which there are eight. The incoming ore was formerly distributed over the tank by means of a rotary feeder in order to prevent segregation of the finer particles. Recently this has been found unnecessary and now the ore is simply dumped into the tank through one of the top doors and leveled off. This method of charging gives a light porous bed of ore which is easily penetrated by the solutions. It is advisable to level off each charge carefully to exactly the same depth so that identical volumes of leaching solution will always just submerge the ore. Otherwise costly irregularities in the operation of the plant will ensue, and the capacity of the storage tanks will be taxed by a large amount of idle solution.

While the tank is being charged and during the interval between charging and the application of the first leaching solution, a considerable quantity of water seeps

out of the ore and is allowed to escape by unscrewing drain plugs in the bottom of the tank. If this water were left in the ore it would dilute the leaching solution, and eventually would have to be boiled out of the system in the evaporators at a considerable expense for steam. Therefore this drainage is important, and should be encouraged as much as possible by hurrying other processes to allow a maximum interval for drainage. Plugs are used here because no valve or cock has been found that will remain tight more than a few weeks. Where lines run from one tank to another a little leakage through the valve will cause no loss of solution, and an ordinary all-iron gate valve is perfectly satisfactory, but all pipe ends that lead from the system must be protected by plugs.

The tanks themselves are made of single-lap riveted steel plate about $\frac{5}{16}$ in. thick. It is well to construct the dome top with a short radius so as to furnish added strength against suction, since at times during the steam wash, a vacuum is induced, due to too rapid condensation of the steam, that will buckle a weak top with disastrous results. The same thing occurs when a careless operator pumps solution out of the tank without opening a relief valve on top of the tank. In opposite effect, too much steam builds up a pressure that will cause the flat bottom to bulge and leak badly at about 5-lb. gage. All these difficulties can be obviated by a good safety valve set for small differences both of pressure and vacuum. Such a device, made entirely of iron for ammonia service, has not been found on the market and must be made to order. Vapor pressures as mentioned above are all measured by a mercury manometer.

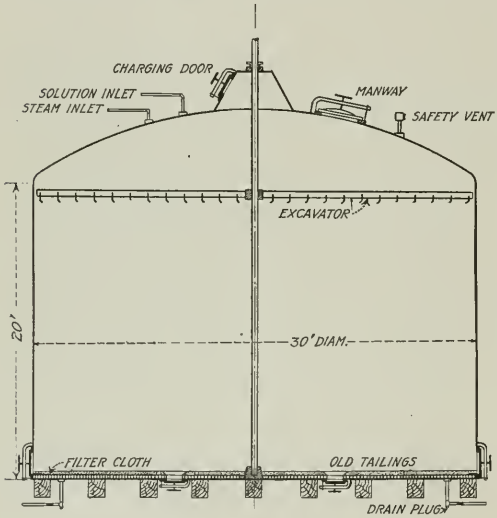


FIG. 2. SECTIONAL VIEW OF LEACHING TANK

Leaks in Tanks a Large Expense

Due to alternate heating and cooling, and to accidental deformations due to excessive pressures, these leaching tanks soon leak at the seams, especially around the bottom, where the pressure is greatest. Recaulking is only a temporary relief, and often leaks come at points of support or at other inaccessible places. These leaks are one of the largest sources of expense in the plant. Constant vigilance must be exercised to detect new leaks and if they are beyond remedy to arrange receptacles to catch as much of the solution as possible. One of the routine duties of the operator must be to collect and empty these drippings. A concrete floor has been placed under each tank to catch leaks, but it fails in its purpose because so much water gets into it in one way or another that any ammonia solution is diluted to a point where it does not pay to save it. The writer believes all this difficulty can be eliminated by electrically welding the tanks when they are first installed. It is doubted whether this would prove successful on tanks which have been long in service and whose seams are coated with silt and scale.

Gage glasses on leaching tanks are unnecessary. If used they must have all-iron fittings which are expensive and hard to get. One should guard against running up the cost of installation with such accessories, which may be convenient, but can be dispensed with.

Filters

The entire bottom of the leaching tank is covered with a filter bed adapted from cyanide practice with practically no change. One thickness of heavy duck makes a satisfactory filter and can be purchased already sewed and cut to fit the tank. To protect this cloth from mechanical wear a cover of "cocoa matting" is placed over it. Both cloth and cover are cut 6 to 10 in. larger than the bottom of the tank, and this flap is calked into a recess left between the tank wall and the wooden grid which supports the cloth. A piece of manila rope calked into the trough holds the cloth firmly in place, and as an added precaution strips of wood are nailed around the circumference on top of the filter and its cover. The grid to support the cloth can be made of fir strips 2 in. high and 1 in. wide nailed together so as to leave a 1-in. space between each two strips. They must be notched on the under side to permit free drainage of the filtrate along the bottom of the tank to the outlets. They must not be fastened with metal clips or strips, because these soon disintegrate in the leaching solution, and lodge in valve seats, pump impellers and other unfortunate places all over the system. After from 18 to 24 months' service the grid becomes soft and pulpy and must be replaced. The life of a filter can be greatly extended by always leaving 6 in. of tailings on top of it when excavating the tank. Under such circumstances filter cloths and covers ought to last 12 months. This natural filter bed must be changed every few months when it becomes saturated with slime. This bed forms a dead space in the tank that will not impart any copper to the leaching solution which occupies it; hence the first few tons of solution drawn off the tank after the first leaching period will be low in copper, and should be run into the weak solution tank to avoid diluting the main part of the rich solution.

Doors

All doors and frames are of cast steel, with finished surfaces where they meet. They can be forced shut on a gasket by means of a screw clamp. The most satisfactory cheap gasket for everyday use on 12 x 12-in. and 12 x 16-in. doors consists of several thicknesses of building paper well smeared with some sticky substance such as paint—cold-water paint is good. This gasket can be used but once. Sheet rubber packing makes a

better but much more expensive gasket that can be used several times. Asbestos sheet and woven packing is yet more expensive and no better. Cotton wicking is always kept for emergencies; improperly packed doors in the bottom of the tank cannot be readjusted after the tank is full, but their leaks can be mitigated by calking with a bit of wicking around the outside.

Piping and Pumps

Under some conditions the ammonia solution has a chemical action on iron. A hot solution containing a little copper will corrode the iron walls of a pipe to such an extent that the pipe is eaten entirely away at the threaded connection after a few months, and has to be renewed. Metallic copper is left behind, and presumably the iron goes off as a hydroxide. After more than two years of continual service the leaching tanks, however, do not show any evidence of such action; it is thought that the solution has to be in rapid motion,

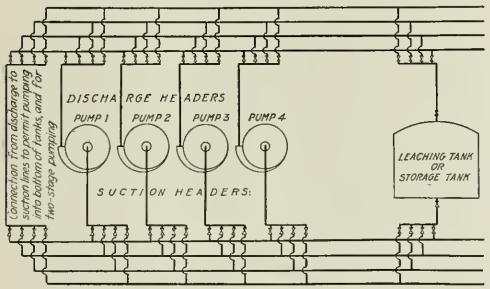


FIG. 3. PIPE AND PUMP DIAGRAM

as in flowing through a pipe, in order to promote corrosion.

It is possible to transfer all ammonia solutions needed in this process with six pumps. There are also a number of pumps required to handle cooling water for the condensers, water for use in excavating the leaching tanks, and other uses determined by local conditions. It is good practice to have not more than two sizes of pumps, make these a standard and have all pumps, both water and solution, in either one or the other of these sizes and of identical make and construction. This means that all-iron ammonia pumps will be used on ordinary water service, but the saving in the initial outlay for spare parts alone will cover the additional cost of the pump. When it comes to piping, a great saving in the money tied up in the warehouse can be effected by installing not more than two different sizes of pipe. For all ordinary work 2-in. piping is ample, both for suction and discharge pipes. By arranging the pumps on interconnected headers, as shown in Fig. 3, it is possible at times to allow two suction lines to discharge into the same pump so as to give ample suction-pipe capacity.

The most satisfactory small size pump which has been tried out is a centrifugal pump direct-connected to an electric motor. Such a pump with a 5-hp. motor and inclosed type impeller will deliver 125 gal. per min. against a 50-ft. head. The inclosed impeller is more efficient than the open type, but must be carefully watched to remove bits of wood and ore that lodge there and cut down the capacity of the pump and of the whole plant. In installing a pump it should be carefully gone over, because manufacturers of "all-iron" pumps obstinately insist on fitting them out with brass petcocks, screws, etc., which must all be taken off before using.

Small reciprocating steam pumps are troublesome affairs to pack and oil, in comparison with centrifugals, and are not very economical unless their exhaust can be utilized. There is an excess of waste heat about a leaching plant as it is, so that ordinarily no use can be found for any such exhaust steam.

Air lifts, where the compressed air comes in contact with the solution, are not favored, because a certain amount of ammonia would be carried off with the exhaust air in the form of vapor. A steam injector might prove very feasible for the purpose of charging the rich solution into the evaporators, where the heating of the solution would be a desirable feature. An all-iron injector for this purpose has been under consideration for some time. At present the evaporators are charged by a 10-hp. 4-in. centrifugal pump, which is our large standard pump.

Filtrate From Evaporators Hard to Handle

The most difficult solution to handle is the filtrate from the evaporators, or "boiled-out solution," as it is called. It is hot and contains enough dissolved copper to act strongly on the iron valves and piping. Valve wedges and stems will be put out of commission after only a few weeks' service. There is also copper oxide present which has leaked through the filter cloths and is carried along in suspension. This acts like emery dust, quickly cutting the shaft and thrust-bearing surface of a pump. The most satisfactory method of handling this material has been to apply steam pressure to the filtering tanks, so as to force the liquid through the filter cloth and out to the settling tanks.

Operating a centrifugal pump is something of a fine art at best, and with ammonia solutions new symptoms develop which a novice would fail to diagnose. For instance, in pumping strong ammonia solution, the reduction of pressure in the suction pipe causes some ammonia to vaporize and spoil the priming of the pump. By placing an ammeter on the pump motor it is possible to locate many troubles accurately; it shows whether a gland is too tight, or so loose as to let air suck into the pump (a very common trouble); it detects a plugged pipe line or a valve accidentally left closed. By suitable switch connections one ammeter on the switchboard can be connected to any pump motor at will.

There will always be some leakage about the pump glands; solution pumps should therefore be placed in concrete basins which will save this drip and allow it to drain into a sump. A very important feature about saving these drippings is to prevent them from becoming so diluted with surface water that it will not pay to save them.

It is a great help in "breaking in" new operators to paint the various solution lines with distinctive colors. In fact, if the operator-elect paints these over himself so much the better; assignment to this duty in our plant has now come to mean that a man is "on deck" for an operator's job. Solution pipes should never be buried, but should be left out in the open for easy inspection and repair. Lines carrying hot solution will have to be frequently replaced, both pipe and valves, so a lavish use of unions is good economy.

As for valves, standard all-iron "clip" gate valves are very satisfactory and are standard practice at Kennecott. They usually cannot be relied upon to seat absolutely tight after a little wear. Plug cocks may be used, but in the 2-in. size are very hard to manipulate. Special ammonia valves and fittings, such as refrigerating plants use, are absolutely unnecessary and very expensive. A permanent pipe fitter's bench fitted out with vise, cutters, taps, dies, etc., is a very essential part of the plant.

The Evaporators

The evaporator is the real heart of the plant. It has a twofold purpose: first, to remove the dissolved copper from the system at the rate it enters into solution from the ore, so as to maintain the dissolved copper in a state of equilibrium; and secondly, to remove water from the system as fast as it is introduced from the moisture in the ore and from the steam that enters the system, so as to maintain the volume of solution nearly constant at all times. From the standpoint of economy it is very important to minimize the quantity of water entering the system so as to save steam in the evaporators; in other words, it is better to evaporate a small quantity of solution, rich in copper, than a large quantity of weak solution.

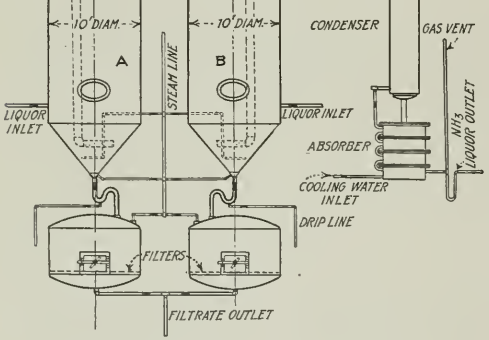


FIG. 4. DIAGRAM OF EVAPORATORS

Fig. 4 shows one of the duplicate units that have been evolved for our use after expensive large-scale experiments with various types of evaporators. While it will no doubt be further modified from time to time, this is by far the most satisfactory type put in operation up to the present.

The great difficulty in evaporator construction and operation has been the hard scale of copper oxide that tends to form over the interior surfaces both of the evaporator itself and also any steam coils or other heating surfaces. This renders the ordinary continuous distilling column with its complicated passages and trays absolutely useless after a few hours' operation. The higher the copper content the more this trouble is aggravated. However, scale will not be deposited on vertical surfaces, or on steep surfaces making an angle of 40 deg. or less with the vertical. Hence the evaporators of Fig. 4 have eliminated all this scale trouble and will run for months without cleaning. There are no heating surfaces to crust, because steam is admitted directly to the solution from a perforated pipe. It is also very essential to admit a jet of steam to the tip of the cone to keep the precipitated copper agitated—if allowed to settle it forms a dead space that would remain saturated with ammonia, and this ammonia would be lost when the precipitates are dumped into the filtering tank. Moreover, settled precipitates are liable to form a cake that will not readily pass through the discharge cock. It is sometimes necessary to start the discharge by means of a long poker worked through the vent in the top.

Details of Operation

At the start of operation both *A* and *B* are filled half-full of rich copper-ammonia solution. In practice this will test 5 per cent copper and 7.5 per cent ammonia. Steam is then turned into *A* only, and the valves in the vapor line set so that the resulting vapors will pass from *A* into the solution in *B*, and serve to heat *B*. The vapors from *B* are passed through the condenser, which reduces the ammonia and water to liquid form. This condensate, together with the noncondensible CO_2 gas, flows downward through the absorber or cooler, the gas bubbling through the liquid so as to scrub out all the ammonia. The liquid is then received in a storage tank and held ready for use again as a fresh leaching solution. The CO_2 escapes through another scrubber, where it is washed with water or a weak ammonia solution.

As the solutions in *A* and *B* commence to become warm the evolution of CO_2 becomes noticeable well before the boiling point is reached. No definite temperature can be set for this occurrence, because it depends on the composition of the solution, but usually the gas becomes noticeable at 130 deg. F., and very large volumes are given off before any ammonia vapor reaches the condenser. Between 160 and 170 deg. F. and under a pressure of 2 to 5 lb. gage in the evaporators, the solutions commence to boil and evolve ammonia vapor. Shortly after the ammonia starts, the evolution of CO_2 dies down and practically ceases. From this point to the end the evaporators show a bad foaming tendency, hence they are filled but half full at the start, and great caution is used in admitting the steam. A practiced operator, however, will easily control his evaporators so that only an occasional trace of copper solution will pass over into the condenser. The first ammonia vapors to go over into the condenser are, of course, very strong, but as the boiling continues they gradually become weaker, until at the end of the run they may be only 1 or 2 per cent ammonia, the rest being water. The average ammonia content of the condensate from a complete run will be about 16 per cent.

After five or six hours' boiling the ammonia content of the solution in *A* will have fallen to less than 5 per cent, and at this point copper begins to precipitate. It first comes down as a green copper carbonate, and would stay in this form unless steps were taken to prevent it. By raising the pressure in the evaporator to over 10-lb. gage, and by keeping the precipitates agitated with the jet of steam in the tip of the cone, the carbonate is changed to the black copper oxide. This latter is a more desirable shipping product, because it will contain more than 75 per cent copper, as against 60 per cent for the green carbonate. However, if the market should develop, a very good grade of copper carbonate could be produced.

Steam is kept on *A* until all but a trace of the copper has been precipitated and the ammonia content of the solution has been reduced to 0.03 per cent. This should require 10 to 12 hours. At the same time the solution in *B* will have been reduced to about 2.5 per cent ammonia, and the copper partly precipitated. Steam is now turned off *A*, the discharge cock opened, and the entire contents dumped into the filtering tank. Next a fresh charge of rich solution is pumped into *A*, steam turned on *B*, and the vapor valves reversed so that vapors from *B* pass into *A*, and from *A* into the condenser. *B* can now be boiled down to 0.03 per cent ammonia and dumped into its filter, and the procedure continued indefinitely.

While the evaporators are boiling, steam is turned into the filter tanks at about 15 lb. pressure, so as to force the "boiled-out" solution through the filter and leave the precipitated copper oxide on the cloth. The precipitate can be dried in this manner to less than 18 per cent moisture, in which condition it is sacked and shipped to the smelter. The filters consist of two layers of 8- to 10-oz. duck, protected by one cover of "hop cloth" and supported by a perforated metal screen. The cloths must be renewed about every four weeks, and the screens every four months. The filtrate should be passed through a series of settling tanks to save the small quantities of precipitate that always go through the cloth and the occasional large amount due to defective filters. The filtrate may also be passed over scrap iron, which will precipitate a small amount of cement copper from the last traces left in solution. If this is done, care must be taken not to allow the cement copper to cool while under the solution, because if it does the trace of ammonia present will redissolve it.

The discharge cocks on the evaporators are 4-in. all-iron asbestos-packed plug cocks, with easily replaceable packing. Every week the plug should be taken out, polished, well oiled, and a new packing inserted. Even with this care, at times the cocks will leak and allow rich solution to escape from the evaporators. However, such leakage may be trapped and saved as shown in Fig. 7.

The condensers are fitted with 2-in. boiler tubes of charcoal iron 12 ft. long, which have to be renewed about every eight months. At least 65 gal. per min. of cooling water must be available for each condenser, although they may not need this quantity all the time.

Plant Control

The services of one chemist are employed on routine analysis of solutions, and experimental work. Analyses of the ore are made in the regular assay office by the mine assayer.

The following simple method of testing solutions for copper and ammonia was worked out by Mr. E. B. Hunn, plant chemist: 10 cc. of solution to be tested is titrated against a standard cyanide solution until it is colorless; the amount of cyanide used indicates the per cent copper in the solution. Another 10 cc. is titrated against a standard H_2SO_4 solution, using methyl orange indicator; the acid reacts with both copper and ammonia until the solution is neutralized, at which end point it takes on a pale green color. From the quantity of acid used, and from the previously determined copper content of the solution, a specially prepared chart enables one to find the per cent of ammonia in the solution. These are the only determinations ordinarily needed to control the plant.

It is part of the operator's duties to sample every batch of solution which is pumped. He takes the samples from the discharge side of the pump through a special cock into a sample-bottle, labels it and leaves it in a rack for the chemist. There is often a wide variation in ammonia and copper content in standing solutions at different depths in the same tank. Due to this stratification it is necessary to take the sample in several equal parts uniformly spaced over the entire time of pumping. The operator also keeps a daily log sheet, on which are entered the time, quantity and disposition of every batch of solution pumped. Once daily he reads the gage glasses on every storage tank and enters this in the log sheet. Most of these storage tanks are 16 ft. in diameter by 20 ft. high, and the scale is calibrated to read in tons of 2000 lb. of solution. This unusual unit of liquid measure is very convenient as to size, and saves a great deal of work when figuring in connection with quantities of ore, which of course are expressed in tons.

It is to be noted that all these measurements, and the titrations for copper and ammonia, are really volumetric, and are accurate measures of weight only when the solution has a specific gravity of unity. This is seldom the case in practice, various solutions ranging from 1.06 to 0.97 gravity, so that for special purposes these differences must be taken into account.

Costs

To say that our leaching expense amounts to $1 per ton of ore treated is misleading. There are some very unusual conditions in Alaska; there is no standard method of keeping mining costs, and the cost of treatment is greater for rich ore than for lean ore. Therefore the following example has been worked out, using the same quantities of labor, steam and ammonia which

EXPENSE OF LEACHING 450 TONS OF CRUSHED AND DESLIMED MILL TAILINGS PER 24 HOURS

Copper (oxidized) content of ore leached..... 0.85 per cent
Copper (oxidized) content of ore tailings..... 0.17 per cent

Gross extraction is 13.6 lb. copper per ton leached. Of this about 1 per cent, or 0.1 lb., must be deducted as dissolved copper lost in the leaching process, leaving 13.5 lb. per ton to ship to the smelter. This is shipped in the form of copper oxide containing 75 per cent copper and 18 per cent of total weight as moisture (per cent copper figured on dry weight). Smelter deductions will amount to 0.2 lb., so that the net copper sold will come to 13.3 lb. per ton leached, or 5985 lb. per day.

Leaching Expense for		Total Per Day	Per Ton	Per Lb. Cu Sold
Direct Labor:				
1 Foreman at	$6 00	$6 00		
1 Chemist	5 00	5 00		
3 Shift bosses	4 50	13 50		
3 Operators	4 00	12 00		
9 Laborers	3 50	31 50		
1 Repair man	4 50	4 50		
Total		$72 50	$72.50	$0.161	$0.0121
Power and Lights:				
630 kw. at 2.5c. per kw. (1.4 kw. per ton)		15 75	.035	.0026
Ammonia:				
0.25 lb. per ton loss in leaching	$0 25			
0.02 lb. per lb. Cu loss in evaporators. 13.5 × 0.02	.26			
Total loss per ton	$0 51			
Cost, at $0.50 per lb. NH_3		114.75	.255	.0192
Steam:				
94 lb. per ton for steam wash	.94			
16 lb. per lb. Cu for evaporation 13.5 × 16	216			
Total steam per ton	310			
Cost at $0.001 per lb.		139 50	310	0234
Maintenance and Repairs: Includes cost of all maintenance of machinery and buildings, both materials and extra labor necessary		25 00	055	.0042
Operating Supplies: Sacks, oil and waste, packing, etc.		15 00	.033	.0025
Total leaching expense		$382 50	$0.849	$0 0640

have been found necessary at Kennecott, but changing the rates somewhat to conform with more usual conditions.

It should be especially noted that the above is the leaching expense only. No charges are included for overhead, mining and crushing the ore, tailings disposal, freight to smelter and smelting charges, or selling expense. Little if any profit could be shown in leaching such a lean ore, if all these charges had to be borne by the leaching plant. But in the case of treating tailings from a primary concentrator, as at Kennecott, it is perfectly proper to charge the mining, crushing and tailings disposal to the main plant, which would have to bear this expense if the tailings were not treated, and under these circumstances it is possible to show a profit with very lean ores. In this connection it should be noted that ammonia and steam expense, which are the two largest items, vary not only in proportion to the tons of ore but also in proportion to the copper extracted. Hence it is not so expensive to treat lean ores. Power, maintenance and supplies will vary as the tonnage, while labor is constant and not affected by either tonnage or production.

As for first cost, construction expenses vary a great deal with local conditions. In the light of past experience, and under normal conditions, it is thought that $300 per ton of ore-treating capacity per day would be a reasonable estimate of the first cost of a small plant as herein described. One large item that must not be overlooked is the initial supply of ammonia. Some 275,000 lb. of 26 deg. aqua ammonia or equivalent must be accumulated, and this may easily cost more than $30,000. Unless skill and foresight are used in manipulating the plant operations, "peak" demands for ammonia will at times call for a much greater supply. The foreman must aim to keep all his ammonia at work all the time, for idle solution represents not only an idle investment in itself, but calls for additional storage tanks, and is a positive loss from leaks and evaporation.

Canaan, Conn.

Semi-Annual Meeting of American Institute of Chemical Engineers

Dr. John C. Olsen, secretary, has announced that the summer meeting of the American Institute of Chemical Engineers will be held at Boston, June 18 to 21, inclusive. A symposium on Electric Furnaces is being prepared. Further details regarding the program will be given in an early issue.

New Jersey Chemical Society

Colonel F. M. Dorsey of Cleveland, Ohio, Chief of the Development Division of the Chemical Warfare Service, will give an illustrated lecture before the New Jersey Chemical Society on Monday evening, April 7. The lecture is entitled "Activities of the Development Division of the Chemical Warfare Service," and will deal particularly with the development of manufacturing methods for mustard gas and for dorsite, or activated charcoal, with which Colonel Dorsey has had considerable to do.

Another item of present interest is a general discussion on "Permanent Results From Wartime Necessities" led by Professor R. G. Wright, of Rutgers College.

Dinner will be served at Stetter's Restaurant, Newark, at 6:30.

Imports and Exports

The Bureau of Foreign and Domestic Commerce of the Department of Commerce gives out the following statistics of imports and exports for January, 1919:

IMPORTS AND EXPORTS OF COPPER, BY CLASSES

Imports

	Gross Tons	Copper Content, Lb.	Value
Ore	11,697	2,919,767	$643,777
Concentrates	9,379	2,505,000	647,600
Matte and regulus	4,341	4,501,623	894,623
Unrefined, etc., in bars		5,065,683	1,256,250
Refined, in bars, plates, etc		4,019,469	983,753
Old, etc., for remanufacture		1,676,525	258,446
Composition metal		3,141	565
Copper manufactures			

Exports

	Gross Tons	Copper Content, Lb.	Value
Ore	1,530	318,946	$65,303
Concentrates			
Unrefined, etc., in bars			
Refined, in bars		72,757,340	18,381,796
Composition metal		8,882	3,238
Old and scrap		25,040	4,518
Pipes and tubes		356,340	137,861
Plates and sheets		3,130,974	884,669
Wire, except insulated		3,289,411	963,793
All other manufactures			526,138

IMPORTS AND EXPORTS OF GLYCERINE, BY COUNTRIES

	Lb.	Value
Imports (total)	15,807	$4,741

Exports

Country	Lb.	Value
Azores and Madeira Is.	163	$30
Norway	4,000	4,000
England	100	35
Bermuda	25	18
British Honduras	14	9
Canada	72,474	40,157
Costa Rica	60	46
Guatemala	300	142
Honduras	150	118
Nicaragua	60	29
Panama	3,876	1,608
Salvador	151	111
Mexico	4,566	2,895
Newfoundland and Labrador	16	9
Barbados	100	58
Trinidad and Tobago	70	60
Cuba	13,690	7,968
Virgin Islands	100	65
Dominican Republic	415	177
Argentina	2,240	1,400
Bolivia	900	720
Brazil	215	150
Chile	1,378	993
Colombia	1,349	926
Ecuador	3,552	1,848
British Guiana	100	78
Dutch Guiana	5	4
Paraguay	50	43
Peru	8,189	3,520
Uruguay	110	94
Venezuela	667	378
China	3,412	2,208
British India	50	44
Dutch East Indies	4,586	3,436
Hongkong	2,050	1,130
Japan	652,522	386,377
French Oceania	30	12
Philippine Islands	6,041	2,794
Belgian Kongo	88	53
British South Africa	18,049	4,912
Total	805,913	468,655

U. S. EXPORTS OF CAUSTIC SODA AND SODA ASH, BY COUNTRIES

Country	Caustic Soda — Lb.	Caustic Soda — Value	Soda Ash — Lb.	Soda Ash — Value
Denmark	112,000	$4,458	1,240,866	$42,266
Italy	1,626,048	129,620		
Norway	60,075	2,523	141,275	6,016
Portugal	350	198		
Sweden	22,400	800		
British Honduras	200	14		
Canada	1,110,649	46,423	3,785,959	97,551
Costa Rica	48,145	2,895	16,500	563
Guatemala	29,607	1,480		
Honduras	27,270	1,511	114,670	4,836
Nicaragua	24,330	1,603	16,400	661
Panama	43,584	2,081	7,000	214
Salvador	28,580	1,759	556	24
Mexico	2,626,192	145,925	357,381	11,053
Barbados	26,400	1,806		
Jamaica	1,218	79		
Trinidad	1,350	82		
Other British West Indies	350	14		
Cuba	629,134	26,398	1,011,350	12,403
Virgin Islands	1,800	182		
French West Indies	6,650	455		
Haiti	100	7		
Dominican Republic	68,822	3,567	6,000	220
Argentina	2,599,953	119,581	248,585	10,733
Bolivia	136,620	7,126		
Brazil	1,740,162	112,976	1,836,587	66,256
Chile	156,500	9,826	110,455	3,498
Colombia	582,041	32,507	165,750	8,910
British Guiana			310	12
Dutch Guiana	7,600	380		
Paraguay	56,025	1,597	64,812	1,202
Peru	282,595	15,321	112,320	5,699
Uruguay	189,367	8,124	97,903	2,443
Venezuela	155,585	7,150		
China	469,766	20,941	908,599	38,092
British India	221,110	11,000		
Straits Settlements	40,000	1,600	17,920	761
Dutch East Indies	11,400	684	64,500	3,225
Hongkong	317,135	17,742	19,000	855
Japan	1,623,548	83,063	3,554,640	125,181
Australia	1,360,284	89,175	974,318	47,951
New Zealand	118,590	9,229	22,400	800
Philippine Islands	816,375	31,847	138,000	7,539
British South Africa	22,275	1,002		
Total	17,402,185	954,751	15,034,056	498,964

Future of Industrial Organic Chemistry

Brief Review of the Several Groups of Industries Depending on Organic Chemical Development, Such as Food, Clothing, Fuel, Drugs and Arts—The One-Plane Basis of Studying Organic Reactions Should Be Abandoned for the Spatial Energy Theory Advanced by Michael

By HAROLD HIBBERT

WITH regard to the late war it may be accepted as a truism that the peace and safety of the whole world rested on a far-reaching knowledge of the underlying principles of scientific and technical chemistry.

A review of our chemical knowledge, both scientific and applied, shows that prior to 1914 the chemistry of the aromatic compounds had been moderately well developed in this country, while that of the aliphatic had been more or less neglected. The reason for this is probably traceable to the influence of the German school of thought. Inasmuch as there existed in Germany large supplies of the raw materials necessary for the production of aromatic derivatives such as toluene, benzene and naphthalene, from which dyestuffs and pharmaceutical products are manufactured, it was natural, in view of the world markets obtainable for these finished materials, that this field should have been developed much more intensively than that of the aliphatic compounds such as the products from wood distillation, grain alcohol, fats, oils, gasoline, etc., all of which were imported products. Not only this, but the dyestuff industry forms, more than any other, the pivot around which so many different manufactures revolve.

In addition, it has always been tacitly assumed that the aliphatic compounds, especially those of saturated character such as the hydrocarbons (gasoline, etc.), are relatively inert materials, and consequently much less "plastic" than the aromatic derivatives; in other words, less capable of being transformed commercially into other products of industrial importance.

Four Main Divisions of War Requirements for Chemists

If we review the war requirements, we find that they may be divided, in so far as the chemist is concerned, into four main divisions:

1. Foods and food products
2. Medical and pharmaceutical supplies
3. Explosives and their intermediate derivatives
4. Poison gases.

A consideration of these shows that the aliphatic chemical compounds have played a rôle equal, if not superior, to the aromatic derivatives. In consequence, university professors, graduate students and technical chemists have, in many cases for the first time, been able to acquire a deep and far-reaching knowledge of the properties of aliphatic substances. If during the last forty years we have specialized on the technical application of the aromatic bodies, it is because it "paid to imitate Germany," but the prediction may now be made with safety that the industrial progress of the next half century will be intimately associated with the development of the chemistry of the aliphatic products.

A consideration of the subject will show that our necessities, comforts and luxuries are all closely related to products of the former class. This is clearly proved among other things from a consideration of the immense capital tied up in the manufacture of products of an aliphatic character. Thus with regard to foodstuffs, we have the vast industry of the edible oils, palm, cocoanut, cottonseed, soya bean, peanut, fish oil, etc.; and closely allied to this, the cyanamide fertilizer industry.

For our heat and light, we require gasoline and candles. Our clothing is derived from cellulose, either in the form of cotton or as artificial silk. Of our medical supplies, it is only necessary to mention such materials as glycerine, methyl and ethyl alcohols, formaldehyde, paraldehyde, chloral, etc. In the matter of luxuries, the moving-picture industry depends on a supply of cellulose derivatives either in the form of nitrate or acetate, while in the late war the most deadly of the various toxic gases employed was the so-called "mustard gas," which in addition to the products already mentioned is also a representative of the aliphatic series.

Value of Aliphatic Materials

Some idea of the value of these materials may be obtained from the following figures:

Value of cotton crop (1918)[1]	$1,616,207,000
Value of natural gas (1917)[2]	142,089,334
Value of products of wood distillation (1914)[3]	10,236,332
Domestic production of vegetable oils (1917) lb.	2,159,335,000
Domestic production of animal and fish oils (1917)[4] lb.	1,636,451,000
Domestic production of butter (1917) lb.	1,369,500,000
Total, lb.	5,165,286,000

The imports of fats and oils in 1917 amounted to 636,288,306 lb., while 584,254,000 lb. were exported. If we compare these with a total value of $40,044,427[2] for the entire output of crude coal tar products (tar, light oils and naphthalene) for 1917 the difference is striking.

The edible oil and fat industry is one of the first magnitude, and yet it will be admitted that the scientific principles regarding the hydrogenation of vegetable oils were first developed scientifically in France, then technically in Russia, Germany and England, and last of all in this country. As in the case of many of the most important technical developments, the work may be traced in its original conception to the scientific researches of Frenchmen, in this case Messrs. Sabatier and Senderens.

[1]Figures supplied through kindness of Department of Commerce.
[2]Figures supplied through kindness of Department of the Interior.
[3]Figures supplied through kindness of Department of Agriculture.
[4]Figures taken from Bulletin No. 769, Department of Agriculture.

While it may be allowed that this country has carefully followed the European patent situation, and endeavored to take advantage of it and improve on the same, yet in so far as the main general scientific aspects are concerned, it has shown relatively little scientific originality. Thus while celluloid is distinctly an American invention, the underlying scientific facts connected with the manufacture of stable nitrocellulose were largely developed through European studies. Without a knowledge of these fundamental properties it would not have been possible to proceed to the discovery that celluloid can be manufactured by compounding cellulose nitrate with camphor. The same holds true with regard to cellulose acetate and xanthogenate, the latter employed in the manufacture of artificial silk.

Universities Responsible for Neglect

There can scarcely be any doubt that the universities are in large measure responsible for the neglect of the study and technical application of the aliphatic derivatives. This neglect would seem to be to a large extent traceable to the faulty method of instruction, and the inability to make a student visualize the products with which he is called upon to deal. In other words, organic chemistry has been made a subject of "blackboard one-plane valency impressions" rather than a consideration of the energy and spatial relations of the constituent atoms in the molecule, and in this latter connection, it is difficult to understand why the work and theories of Michael have not been given much more prominence. The importance of training the student to visualize the spatial relations of the atoms in all organic compounds cannot be overemphasized. Instead of the customary procedure of showing the model of the carbon atom in the one or two isolated cases connected with stereoisomeric and optical derivatives, or in the case of the benzene ring, it would seem desirable to have available, at every lecture on organic chemistry, models which could be constructed so that the nature of the spatial arrangements would be at once apparent to the students, and instead of the customary one-plane representation, it would be possible for them to visualize at a glance the effect of the proximity of the atoms in the molecule and of the effect of the different forms of energy associated with the same, considered from the point of view of their spatial relations.

Thus all of the important properties such as substitution, ring formation, oxidation, reduction, etc., could be taught from this standpoint, and the value of an atom in the 1, 2, 3, 4, 5, etc., position relative to another atom attached to carbon, clearly defined and so thoroughly fixed in the mind of the student that, when called upon to advise on some process in connection with the manufacture of a synthetic product, he would never be at a loss to predict, at least in general terms, the nature of the material to be synthesized, and to indicate some procedure looking toward its successful manufacture.

While not wishing to detract from the interesting researches of Fry and Jones, or from the interesting discussions of Falk and Nelson, as well as of G. N. Lewis, it would seem, in so far as the technical side of organic chemical problems is concerned, that for the present the theories of Michael, though in some respects vague and indefinite, largely on account of the impossibility of providing all the quantitative data, yet at the same time do provide a working hypothesis which undoubtedly assists the research chemist to a remarkable extent in predicting the nature and course of chemical reactions and of the properties of unknown chemical individuals.

If a student learned to grasp thoroughly the fundamental principles underlying the relative energy values of the atoms in the molecule, and to obtain a more profound and comprehensive knowledge of the facts of catalytic phenomena bearing on organic chemistry, he would be placed to-day in a far more advantageous position for solving the various technical problems arising in connection with the development of outlets for the commercial and industrial utilization of naturally occurring products found in this country.

Pitfalls of the Young Chemist

The young research chemist in the industry is too apt to attempt to transfer his college knowledge of the "type properties" of any chemical compound to the derivative to be synthesized instead of realizing that the problem to be solved is in general one in which, for some reason or another, the "type property" has either ceased to exist, or has been considerably modified through the influence of certain groupings or atoms in the molecule. Thus he fails to realize that a reaction of any group such as carboxyl or hydroxyl, instead of representing a definite fixed property *per se*, is in fact rather a summation of properties representing a combination of the play of the various energies and affinities of the entire reacting atoms comprising the molecule; in other words, the group does not exist alone. It is this understanding and appreciation of the varied influence of each atom in the molecule on each other atom which enables the trained chemist to predict chemical phenomena and properties, and as the ability to predict is a true measure of the ability to invent, and invention and progress naturally move hand in hand, the importance of such knowledge is readily apparent.

Much has been heard of the various psychological tests employed in the Army, and it would seem that equally satisfactory tests applicable to college men desiring research positions should be devisable. One suggestion in this connection is that at the conclusion of the usual course of organic chemistry a series of seminar exercises should be given in which, by the use of models, the students should be called upon to give indications of their ability to predict the nature and properties of different chemical compounds. Thus, for example, with a compound of the formula

$$\begin{matrix}CH_3\\CH_3\end{matrix}\!>\!CCl - CH = CCl - CH_2 - CH_2 - NH_2$$

which preferably should be written

$$\begin{matrix}CH_3 & CH_3\\ & CCl\\ HC & NH_2\\ \| & |\\ CCl & CH_2\\ & CH_2\end{matrix}$$

the student could be asked to set up the carbon models, and then, with these in full view, he asked to predict the effect of various reagents on the various atoms in the molecule; in this case, the tendency toward ring formation, the action of alkalis, effect of oxidizing

agents, removal of halogens, properties of the different hydrogen atoms, etc. A satisfactory answer to such questions would, from the technical research standpoint, provide evidence much more valuable of the man's probable research ability than reams of paper dealing with his knowledge of the dozen different ways for making, let us say, ethane or other derivatives.

The fact that acetaldol can be made by the condensation of acetaldehyde with alkalis, etc., and the various conditions which must be observed in carrying out such a reaction are of less importance than the ability to predict, for example, just in what manner, say, acetaldehyde would condense when mixed with some other aldehyde, for instance, isobutyric aldehyde.

The same is also true of the ability to foresee, for example, the point at which substitution will occur when a hydrocarbon, for instance, propane, hexane, etc., is subjected to the action of bromine, etc., or again where it will occur in the case of acids and acid chlorides.

These problems and many others of vital interest and importance are to be found discussed at length in the published work of Arthur Michael.[5]

The Training of the Professor

So much for the training of the chemist. With regard to the training of the professor, it would seem that he also stands in need of overhauling. In the first place he has been, from time immemorial, both badly underpaid and overworked, and both of these conditions call for urgent and vigorous action. No professor or instructor can undertake research work unless he is

1. Competent to undertake the same
2. Has adequate facilities in the way of post-graduate men and equipment
3. Has the necessary time to devote to it
4. Is adequately recompensed so that he can be free to devote himself to the scientific side of the subject without the necessity of burdening himself with onerous and uncongenial outside employment.

Granting this, there still remains the fact that the average university and college professor has hitherto not been in touch with the problems of the industrial world. He has, in fact, in many cases rather scorned any association with such, and naturally the industry has resented this and returned the feeling with interest. If the war has shown one thing, it is this, that the future generation of research chemists and chemical engineers will expect from their professors something more than a general knowledge of the theory of the subject, and will at least expect that they shall be conversant with the better known technical applications. As for the detailed knowledge, presumably this will be left to the director of the department of industrial chemistry, between whom and the professor of pure chemistry there should naturally exist the closest kind of personal friendship and scientific co-operation.

Universities to Teach Industrial Chemistry

Various universities, including Harvard, have now made a start in this direction by establishing departments of industrial chemistry, and it is to be expected that other universities such as Yale, Princeton, etc., will follow her lead. Unless this is done we shall undoubtedly fall behind other countries, as witness the marked progress being made along these lines in England and the subsidizing of English university professors by manufacturers of explosives and other chemicals with a view to utilizing the services of their highly trained intellects in the solution of different technical problems.

Various corporations in this country have already allocated considerable sums of money for similar purposes and it is now for the universities to decide as to how far they can, and will, co-operate with them in this. Instead of a series of Mellon Institutes dotted over the country, the more logical development would seem to lie in the creation of strong departments of industrial chemistry at the leading universities.

That there need be no lack of subjects requiring investigation is especially evident when we consider the natural resources of this country, and how closely their development is identified with a thorough knowledge of the chemistry, in particular, of the aliphatic compounds.

In this connection it may be of interest to take up the subjects indicated previously, namely:

1. Food products
2. Clothing
3. Fuel for light and heat
4. Medical supplies
5. Luxuries and arts,

and to glance briefly at the progress and developments which have been made regarding these during the last few years, and at the same time to indicate the general trend of future industrial development.

Slogan Should Be "Tolerate No Waste"

In the first place, in view of the recent prodigal waste of the world's resources, it is now necessary to "think internationally" as well as nationally. After all, the world's resources are not unlimited, so the slogan of the chemist from now on should be, "We shall tolerate no waste." As an illustration of this, if it can be shown that our entire supply of ammonia can be obtained from the coke oven gases, then it would seem logical to enact the necessary legislation to enforce the introduction of the recovery system to the entire coke industry, while other processes, such as the manufacture of cyanamide, which encroach on our limited available supply of coal and power should, if necessary, be excluded from the manufacture of such material.

In the same way if we can produce the country's requirements of alcohol and acetic acid economically from such materials as waste wood, which it must be admitted seems rather unlikely, then from the "world conservation standpoint" these processes should logically receive more attention than when prepared by other methods involving the use of raw materials, limited in extent and capable of being adapted more effectively and efficiently to other branches of the arts. In this connection it is also true that the manufacture of ethyl alcohol from waste pulp sulphite liquors, if possible from a commercial standpoint, is also true conservation when considered from the point of view of the utilization of foodstuffs such as corn, etc., for the same purpose.

What can the technical chemist do to assist in bringing down the high cost of living? How can the universities, colleges and scientists assist him? A brief attempt will be made to answer these questions. Concerning the list previously quoted, namely, food products, clothing, light and heat, medical supplies and luxuries, an examination will show that they are ar-

[5] See, among others: *Journ.* pr. chem. 60, p. 286-409 (1899); 68, p. 487-520 (1903). Berichte 34, 626; 4028 (1901); 39, 2138 (1906). *Journal* Amer. Chem. Soc. 32, 991 (1910); 40, 1674 (1918); 41, 393 (1919).

ranged in approximately the order of their importance with regard to the development and protection of the individual.

Food Products

For the first time in their lives millions of people have been forced to learn, during the last four years, something regarding the nature of food and food products. As is well known, the bodily requirements comprise three main divisions, namely, fats, carbohydrates and protein, a shortage of any one of which proves disastrous.

With regard to fats, these are aliphatic compounds, esters of glycerine and fatty acids, and owing to their utilization along lines other than for food, a very pronounced world shortage soon occurred in this field after the outbreak of the war. As is well known, fats are utilized for the manufacture of glycerine and fatty acids, the latter being converted into soap and various other useful chemical products, while the glycerine finds its main outlet in the manufacture of explosives, cordite, dynamite, etc.

An increase in the available supply of edible oils thus became imperative, and the production of cocoanut, peanut, palm, soya bean and other vegetable oils, together with animal fats, was stimulated to a very marked extent, and yet in spite of this the shortage abroad remained very acute. All of these oils represent aliphatic derivatives, regarding which much research work is necessary and from which, in turn, marked technical advances may be expected. Thus soya bean oil is comparatively a new product and is produced now in such large quantities that additional outlets for the material are desired. In 1918 we imported from China and Japan 335,983,492 lb., having a value of $35,454,639.

The properties, chemical, physical, etc., of peanut oil would seem to repay investigation, and the general question of prevention of rancidity in oils, especially in the case of cocoanut and palm oils, is a subject calling for the attention of the chemist. A good cheap commercial method has been developed for the deodorizing of fish oil so that the low grades, which on account of their high fatty acid content cannot be used for purposes of hydrogenation, can now be employed for the manufacture of glycerine and soap.[6] This question of the hydrogenation of fatty acids is a field offering considerable scope for the research chemist, as is also the problem of the catalytic reduction of unsaturated aldehydes and ketones whereby unsaturated alcohols may be obtained.

The oils extracted from peach kernels and other waste raw materials have also been shown to provide useful substitutes for olive oil as salad dressings, etc., so that a more extensive use for these materials may be predicted.

Carbohydrates

There also developed during the war period a considerable shortage in the supply of sugar, due in part to the inability to transfer supplies from one part of the world to another, notably from Java and other points. In consequence of this, the saccharine industry was developed both here and abroad, and some idea of the value of it may be gained from the fact that at one time in England this material sold for about $80 per pound, and it became customary for individuals to carry around small saccharine pills for the purpose of sweetening their beverages. In view of the fact, however, that saccharine is not a foodstuff, it is not likely that the manufacture of this material will be pushed to a considerable extent after the war except in the case of a few industries such as the mineral water trade, and up to the present no other substitutes have been developed and in fact they do not seem desirable. There would seem, on the other hand, to be a good opening for the development of special carbohydrate material capable of being assimilated by people suffering from diabetes.

Protein

It is probable that in the domain of the protein foodstuffs most progress is possible. The extensive researches carried out, for instance, at Yale might well be utilized for the purpose of testing out the relative value of a pronounced protein diet in comparison with one entirely vegetarian. It would be of considerable interest to divide, say, a given class into two such squads, and then to have a full report at the end of a nine-months' period as to the mental and physical condition and development of the individuals in each series.

It does seem surprising that in view of the well-known facts regarding the protein content of peas, beans, lentils, cheese, etc., there should still exist doubt in the minds of college men, chemists and others that such materials are not adequate to provide the full protein requirements. When men of such eminence in the inventive world as Dr. Leo Baekeland and others testify that their best work was done on a strictly vegetarian diet, it provides considerable solid ground for the assumption that such conduct would also be of advantage in other cases.

In this connection a few facts concerning the soya bean industry may be of interest.[7] The bean itself is grown principally in China and Japan, and the development of the oil industry has been most marked within the last twelve years. In fact, had it not been for this commodity the probabilities are that many of the soap factories would have had to suspend operations during the last two or three years. It is claimed that this country could use some 600,000 tons of soya bean oil annually, corresponding to 6,000,000 tons of soya beans. In 1918 the total imports from Manchuria were approximately 1,000,000 tons of beans, equivalent to 100,000 tons of oil. There were imported into this country in 1917 approximately 132,000 tons of oil, while the domestic production amounted to 21,000 tons.

Soya bean oil resembles linseed oil to some extent, that is, it is a drying oil and has been used largely in the manufacture of paints, linoleums and similar products. On the other hand, it is a valuable constituent of salad oils and butter substitutes and in China forms the staple food oil of large classes of the people.

Dietetic Value of the Soya Bean

Due to the fact that with ordinary methods of cooking soya beans remain rather unpalatable, their use, as such, has not been practiced to a great extent, but the

[6] It is stated that in consequence of the inability of trawlers to operate in the North Sea and other portions adjacent to the British Isles, the fish have multiplied very rapidly, so that it is expected the fishing industry will be very active during the next few years.

[7] The data are compiled from an interesting article, "The Romance of the Soya Bean," by L. S. Palen, published in the January (1919) number of *Asia*, the journal of the American Asiatic Association. The U. S. Department of Agriculture Bulletin No. 439, "The Soya Bean," by Piper and Morse; and No. 769, "The Production and Conservation of Fats and Oils in the United States," by Bailey, also contain much interesting and valuable information.

various sauces, curds, cheeses, etc., made from it have been shown to possess such marked dietetic value that there is likely to be a rapid increase in the future consumption of these products which would tend to lower the high cost of living. Analysis shows the presence of:

	Per Cent
Proteins	30 to 46
Oil	12 to 24
Carbohydrates	24 to 28

According to Osborne and Randall,[8] "The proteins of the soya bean, unlike those of other leguminous seeds thus far investigated, are adequate for promoting normal growth. . . . So far as we are aware the soya bean is the only seed hitherto investigated, with the possible exception of flax and millet, which contains both the water-soluble and the fat-soluble unidentified dietary essentials or vitamines."

However, it is not possible to enter into a lengthy discussion of the subject except to point out that the valuable results obtained in dietetic studies at Yale and other universities should be made more readily available and that at least one or two lectures on this subject should be devoted to the same in any college course on organic chemistry.

Cheap Fertilizer a Necessity

With regard to the whole question of food supply, it is necessary that cheap fertilizer should be provided, and the vigorous and active research being carried out with regard to the recovery of potash from blast furnaces and the cement industry, together with the various new methods for the fixation of atmospheric nitrogen, would seem to warrant the hope that considerable success may be expected from the experimental and technical researches at present in progress.

At present the Haber process would seem to be the cheapest method of nitrogen fixation, but it is rational to assume that the maximum efficiency with regard to the arc process has not been reached, and that valuable improvements and developments may be expected along these lines. Furthermore the difficulties incidental to operating the Haber process at lower pressures are, as yet, far from being solved.

With regard to various by-products of the food industry, some outlet, for example, should be found for cottonseed hulls and similar materials. Preliminary experiments carried out by the writer appear to indicate that when compounded with nitrocellulose cork substitutes may be made, possibly applicable to manufacture of cork stoppers, lifebelts, etc., and this is only one of many uses to which this material might be applied.

Of other points of interest connected with the food industry, there is the question of obtaining suitable oils for use in the manufacture of tin plate and the "quenching of steel." Instead of the edible palm oil other cheaper material such as cottonseed, pine oil, etc., are apparently capable of substitution.[9] Finally, with regard to the extraction of oil from the oil cake, it is recognized that the best solvent for this purpose is trichloroethylene. This is obtained from acetylene and chlorine and is not manufactured in this country at the present time, although its synthesis is not a difficult matter to carry out commercially and it is to be hoped that domestic manufacture of the material will be undertaken.

With regard to the second item listed above, namely, clothing, we find on investigation that in addition to the use of cotton as such, the manufacture of artificial silk has been developed to a remarkable extent in this country in recent times. Furthermore, it was very evident during the last two years that the country's entire available supply of knowledge regarding the scientific character and fundamental properties of certain cellulose derivatives such as the xanthogenate, and particularly the acetate, was decidedly limited in extent. It is a startling fact that while the value of cotton and cotton products such as nitrocellulose, artificial silk, etc., produced in this country is far greater than that of the rest of the world combined, yet so far as a hasty search of the literature shows there has not been a single outstanding scientific paper published in this country on the constitution of cellulose.

We have allowed the European countries to develop the scientific data on these subjects, and then made a feeble, belated attempt to obtain control of the technical applications either by purchase or otherwise. It is regrettable that in the case of the one or two large companies which have carried out scientific work in this field they should have felt under no compulsion to communicate the broad scientific results to the general body of chemists, but prefer instead to surround the matter with a complete veil of secrecy. It is not in this way that the progress of any industry can be assured, and fortunately as a result of the war, this would now seem to be much better recognized.

Fuel for Heat and Light

When we consider the bearing of aliphatic chemistry on the question of heat and light, we find this country is by far the largest producer of petroleum and gasoline products, and not only this, but it is also the largest producer of benzol, of which advantage is now being taken in connection with gasoline mixtures for use in motor cars. There would also seem to be a valuable field in the development of materials of low nitration for admixture with kerosene for use as a motor fuel. Furthermore, it is a pity that there should still be any waste of natural gas, and this material would seem to warrant the close attention of chemists and technologists from both the scientific and industrial standpoint. The action of halogens, condensing agents, contact reactions with unsaturated derivatives, etc., are all interesting fields.

The cracking of petroleum has been developed to a remarkable extent, but it would seem that there is still room for processes involving the use of other contact materials which would enable this operation to be carried out at both a lower temperature and pressure. Possibly additional research would show the advantage of metallic chlorides other than aluminium. The reactions of hydrocarbons with sulphur chlorides would also repay investigation, and the interesting experiments recently carried out with nitrosyl chloride[10] possess much interest both for the scientist and for the technical chemist.

Prior to the war, this country was almost entirely dependent on Germany for its pharmaceutical supplies. In tracing the reason for this, one fact is quite evident, namely, the close co-operation which existed there

[8] *Journal of Biological Chemistry*, December, 1917.

[9] See Department of Agriculture Bulletin No. 769, page 23, "The Production and Conservation of Fats and Oils in the United States" (1919). This is a very valuable monograph, containing, as it does, the latest available information on the subject of edible oils.

[10] *Journal* Amer. Chem. Soc., Vol. 41, p. 368 (1919).

between the universities and various pharmacological institutes on the one hand, and the industry on the other. Such well-known remedies as antipyrine, veronal, etc., were developed in university and not in technical laboratories. We still find it necessary to consult German text books and monographs for much of our information, and it now appears that the compilation and publication of such treatises on highly specialized subjects were carried out in many cases at public expense.

Is it asking too much that this Government should co-operate both actively and financially in the founding and support of a national pharmacological institute such as proposed by Dr. Charles Herty, and at the same time show its willingness to undertake the financing of the publication of scientific memoirs not warranted commercially through the usual channels?

Inviting Field for Organic Research Chemist

The scientific development of the relation of constitution to pharmacological action is one of the most inviting fields for the organic research chemist at this moment, and it is highly desirable that there should be a much closer co-operation between the biologist on the one hand, and the organic chemist on the other. It would be a grave mistake, for instance, not to take advantage of the wonderful spirit of co-operation in this field, developed as a result of their combined activities in the domain to toxic war gases. It is, for instance, inconceivable that the salicylates should represent the only type of compound best adapted to the use to which they are put, and it would seem extremely probable that active research would develop the use of better and more suitable products.

If for instance just one-half of the scientific work expended on the preparation and investigation of toxic war gases during the last two years were devoted to investigations looking to a remedy for tuberculosis, it is reasonably safe to assume that some cure would be found. In this connection it is necessary to recall the wonderful advances that have been made in the domain of biological chemistry, and referred to by Francis H. Carr in a recent lecture on "The Synthetic Organic Chemical Industry."[11]

Cure for Consumption Possible

For example, thyroxin, the principle contained in the thyroid gland, which regulates the rate of body metabolism, is now stated to be an oxyindole derivative of iodocyclohexane, and is so active that 0.3 mg. raises the body metabolism 1 per cent. The fact that thyroxin contains iodine is of considerable interest, since, as shown by the writer[12] and others,[13] a small trace of this element is sufficient to bring about the condensation of hydroxy, amino and imino derivatives. From the recent publication of Van Os[14] it would appear that the iodine present in thyroid preparations does not exert a marked influence, but in view of its remarkable activity as a condensing agent these results should not be regarded as final and conclusive. This is all the more necessary in view of the fact that in the case of tubercular patients the iodine content of the thyroid gland apparently varies appreciably from the normal, so that if some such connection could be traced, it might possibly provide a welcome guiding light as to a possible synthesis of a derivative capable of application to the cure of this terrible scourge.

When we consider broadly the nature of the products on which we depend for our enjoyment, we are again brought face to face with the aliphatic derivatives. The amusement of a large portion of the population at the present time is derived from moving-picture houses, and as is well known the films are made from cellulose nitrate or acetate. Our paper drinking cups and food containers are coated either with paraffine or nitro-cellulose and the casing of the sausage we eat is also probably a modified cellulose derivative.

No matter to what domain of the fundamental requirements of human activity, physical or social, we turn, it is evident that we are brought face to face with the properties and industrial applications of the aliphatic chemical compounds. Not only is it the duty of the chemist to develop the scientific and commercial application of such, but also to foresee and protect the individual from the harmful effects of abnormal natural and artificial conditions. Thus at the present time we are faced with national prohibition, and as this will render idle an immense amount of equipment, it is to this extent destructive of industry.

Problem of the Chemist

The problem of the chemist is, therefore, to provide other outlets for this valuable machinery, and since the production of spirituous liquors is essentially a fermentation process, the attention of the chemist should naturally be devoted to new developments along such lines. Thus the manufacture of lactic, butyric and citric acids could be still further developed together with special sugars such as maltose and food products derived from these, for example, lacto-maltose, etc. The manufacture of special sugars could also be undertaken and it is natural to assume that there will be a much increased demand for essential oils and flavoring extracts for the soft drink industry.

In the second place, one of the effects of prohibition will be to diminish the supply of fusel oil, in turn of amyl acetate, so that in all probability brewery equipment could be utilized for the manufacture of substitutes for these materials; in fact, certain cheap derivatives of lactic acid would form useful substitutes for amyl acetate.

Other Fields for the Chemist

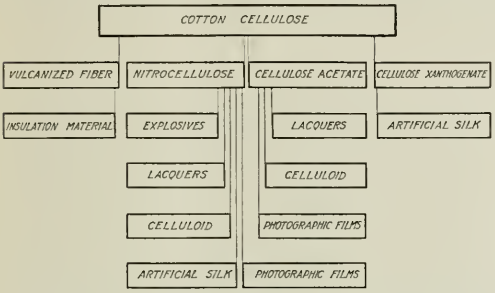
It is not possible to more than mention other fields in which the services of the chemical expert in aliphatic chemistry can find a suitable outlet such as utilization of acetylene, sulphite pulp waste liquor, and especially in the utilization of waste wood products, etc., but the diagrams shown herewith are of interest as indicating the varied outlets for one raw material, namely, cellulose. These show outlets already developed, but indicate little or nothing of the vast unexplored territory still remaining.

Thus, with regard to nitrocellulose and cellulose esters generally, there is a very fertile field for a series of investigations relating to the question of solubility of these products in organic solvents through which much light might possibly be thrown on such problems as the physico-chemical nature of solution, the colloidal state, the theory of partial valency, etc. All of these await in turn the development of some theory as to the structure of the cellulose molecule. The chemistry of the cellulose esters is as yet a com-

[11] *Journal*, Soc. Chem. Industry, Vol. 37, p. 425 (1918).
[12] *Journal*, Amer. Chem. Soc., Vol. 37, p. 1748 (1915).
[13] D. R. P. 241,853; 250,326.
[14] *Pharm. Weekblad*, Vol. 55, pp. 1426-31 (1918); Amer. Chem. Soc. Abstracts, Vol. 13, p. 362.

paratively unknown field, regarding which the industry is forced to rely almost entirely upon empirical data.

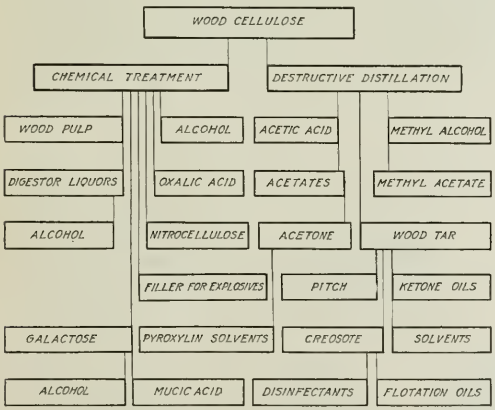
In another direction when we turn to the manufacture of celluloid in this country, the furtherance of the industry itself is dependent on the good will of the Japanese Government in selling us camphor. It would



seem imperative on the part of the American scientific chemist and chemical manufacturer to solve this problem by undertaking the manufacture of synthetic camphor or by carrying out a vigorous search for substitutes for this material, or by doing both. In this connection it would be of considerable assistance and value to the research chemist if the celluloid companies would be willing to explain for their benefit something with regard to the special and peculiar properties which a true substitute must possess.

The Wood Distillation Industry's Future

In the utilization of the constituents of the oils obtained from wood distillation, there is an interesting field of vast extent open to the research chemist. In view of the difficulty which will be experienced in obtaining raw material in Europe during the next twenty



or thirty years, it would seem that the wood distillation industry in this country is in an exceptionally favorable situation for development, and for the supply of products such as solvents for the varnish, artificial leather and lacquer industries; while as regards beechwood creosote, beechwood creosote carbonate, guiacol, etc., the country should be self-sustaining and not have to rely on foreign manufacture.

It is the function of the organic chemist to find outlets for the vast surplus production of aliphatic derivatives such as butyl alcohol, methyl alcohol, grain alcohol, acetone, etc., and to ascertain how far the new scientific facts developed during the last few years by the use of bodies such as phosgene, sulphur, chloride, aluminium chloride and of contact materials, for example, oxides of aluminium, thorium, nickel, etc., may be applied commercially.

In view of the extent to which the aliphatic compounds enumerated above enter into all of our daily life, the importance of a thorough study of these cannot be overemphasized. To assist in this the university and college teachers must of necessity themselves have learned to grasp the fundamental facts concerning the nature of these natural products so that their students may be trained to acquire the habit of thinking of such not merely in the light of formulæ made up of so many letters and strokes, but as combinations of different forms of energy capable of the most diverse transformations.

The old idea of fatty hydrocarbons as inert material must also be relegated to oblivion, and the mind directed to ascertaining how far such products, by the employment of better known catalytic and other methods, can be rendered valuable to the industry.

2 Rector Street,
New York City.

Good Flotation Oils From Crude Tar Products

The new "flotation" process for the concentration of various sulphide ores has had a rapid development in the last few years, and as a result the demand for flotation oils to use in the process has been very great. Pine oils and tar oils obtained by the distillation of Southern pine have become standard flotation oils, but the tar oils obtained by the destructive distillation of hardwoods have not been used so widely.

Recent investigations by the chemists of the Forest Products Laboratory, U. S. Forest Service and the Bureau of Mines have shown that several hardwood tar oils have a very high flotation value. Some of the crude tar products obtained in the ordinary operation for making wood alcohol made especially good flotation oils and in general these crude products were better than any of the redistilled oils obtained by further refining.

Zinc for Rail Bonding

The American Zinc Institute, in its campaign to increase the uses of zinc, is advocating spelter for rail bonding purposes. One of the largest street railway companies recently made a considerable purchase of spelter for use in the manufacture of its Nichols joints. Engineers in charge of bonding operations report that, viewed from price and adaptability standpoints, spelter is unexcelled for such work. Zinc is comparatively plentiful and relatively cheap, and in many directions it is satisfactorily taking the place of more expensive metals.

Decomposition of Metals

Owing to lack of space the second installment of the article on "Decomposition of Metals," by Col. A. J. Krynitzky, is omitted from this issue, but will appear at an early date.

Observations on So-Called "Flakes" in Steel

An Examination of Nickel Steel and Carbon Steel Transverse Test Bars Showed That Abnormalities in Fractures Were Associated With Impaired Physical Qualities and Exhibited More or Less Minute Slag Inclusions, While No Parallelism With Micrographic Characteristics Could Be Demonstrated

By HAAKON STYRI

MOST steel works which have produced war materials have had the annoying experience of getting rejections on account of low physical tests, particularly elongation and contraction, often associated with irregular spots in the fractures.

These irregularities are popularly known by the name "flakes," a name which may serve the purpose when meant to include all types of irregular spots in fractures, but is poor terminology when used for certain types without further qualification. Some accompanying pictures of fractures will show different types of such "flakes." We have small bright spots of a fine crystalline mass radiating from a kernel (Fig. 1), coarse crystalline shiny, leafy spots, the so-called "snowflakes" (Fig. 2), fibrous laminated spots (Fig. 3), smooth velvety bright spots (Fig. 4), flaws and holes (Figs. 5 and 7), and sometimes no distinct spots, but the whole fracture, indicating "rotted" material (Fig. 8).

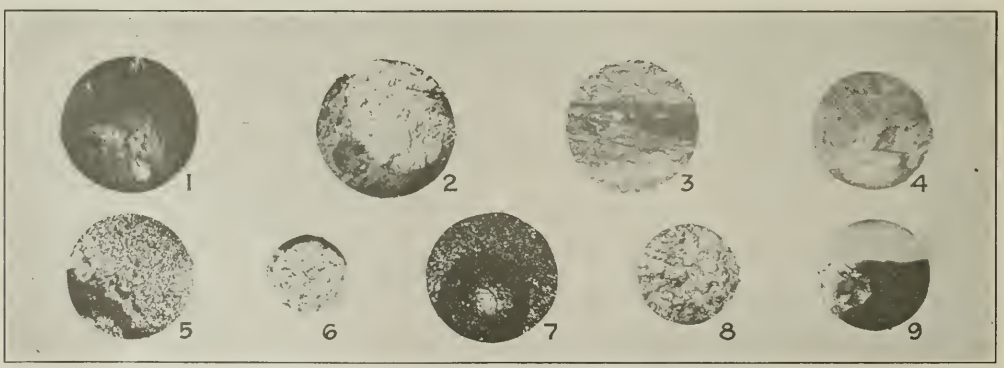
Flakes have mostly been noticed in transverse test bars from nickel steel, but are also found in other classes of steel, and there is a multitude of opinions as to their cause, ascribing them to the melting, the casting, the forging, the heat treatment, or to any combination of these operations. That no single theory covers the whole problem is evident, since flakes still are very frequent in spite of all the work that has been done to eliminate them. So far it seems fairly well established, however, that the ordinary chemical analysis of the heat does not indicate whether flakes will occur in test bars or not.

The present notes, which are very far from being complete, owing to the difficulties of securing research material during war time and the limited time at the author's disposal in which to prepare the samples, perform the microscopic examination and the photographic work, are presented in the hope that they will throw some additional light on the problem. With the effective and untiring help of Prof. F. Crabtree of the Carnegie Institute of Technology, the author succeeded in getting most of the research material from several interested steel companies, and a little from inspectors of ordnance for the Army and Navy. In the paper, the sources are named "party A," etc., because the companies do not want their names mentioned. The different nickel steels were made in electric, acid, and basic open-hearth furnaces; the carbon steels were made in an acid open-hearth.

Microstructure Inconclusive

Microstructure of the first samples of test bars from party A sent to the author for examination are shown in Figs. 10, 11 and 12, which show respectively the fractures of a nickel steel test bar with a good normal cup fracture, and of rejected bars with an irregular and a fibrous laminated fracture. Information on the exact heat treatment could not be obtained, but was thought to be practically the same, while the chemical composition of the steel is identical. Figs. 13 and 14 give the microstructure of a similar nickel-steel with another heat treatment and representing respectively the structure of a test bar with good cup fracture and of a rejected bar with an irregular fracture.

The metallographic analysis showed that different kinds of microstructure (and therefore heat treatment) have no influence on the actual occurrence of flakes.



FIGS. 1 TO 9. VARIOUS TYPES OF ABNORMAL FRACTURES

Fig. 1. Fracture of bar 218 from party B, with bright radiating flake. × 2. Fig. 2. Fracture of bars from party D; coarse-crystalline shiny "snowflakes." × 2. Fig. 3. Fracture of carbon steel bar 2399-2 from party G, with fibrous laminations. × 2. Fig. 4. Fracture of carbon steel bar 234 II from party F, with velvety flake. × 2. Figs. 5 and 6. Fractures of two adjoining test bars from piece 3872 furnished by party F; Fig. 5 shows flaws; Fig. 6 is normal cup fracture; see Table VI for physical properties. × 1.5. Fig. 7. Spherical flaw, crystalline in center, bar 3070 D, from party F. × 2. Fig. 8. Fracture of "rotted" metal in 55G1 from party F. × 2. Fig. 9. Shining, smooth flaw probably from an unwelded blowhole in M53D from party F. Smooth part is polished back for microscopic examination. × 2.

Flaky test bars and good test bars with cup fracture are both found with practically the same microstructure, which can be: pure sorbite, fine ferrite network with sorbite, coarse ferrite network with Widmanstättian structure, and with different kinds of sorbite, or ferrite with pearlite. But examples were found that show an improvement in the quality of the steel with proper heat-treatment, which, however, has not eliminated the flakes.

No Nickel Silicates in Nickel Steel

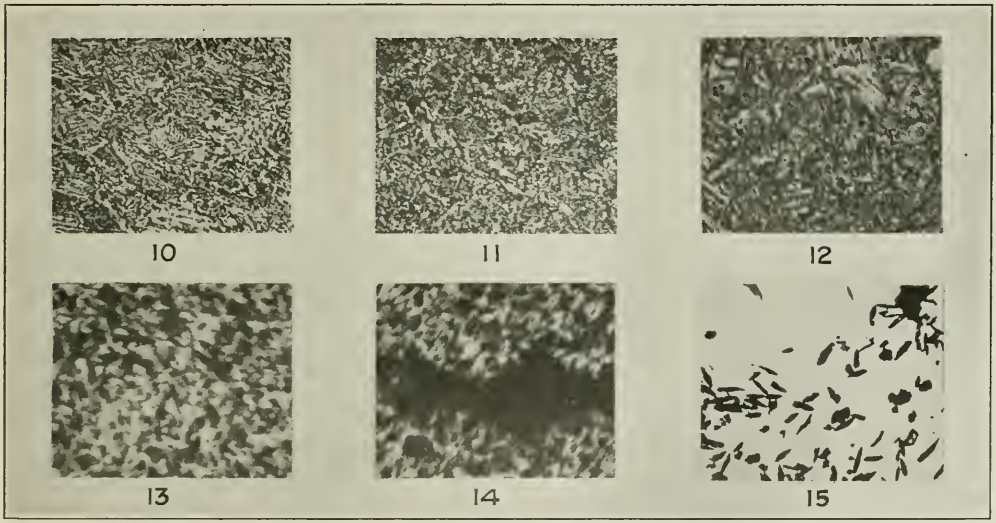
When an opportunity was given the author to examine the fresh fracture of rejected test bars with a binocular microscope it was found that the fractures showed a considerable amount of green slag particles. With this as a clue, I tried to ascertain the nature of such inclusions by microchemical analysis, which proved to be a very difficult matter because the slag particles were so very small. In the literature, it has been generally assumed that these faulty fractures mostly occur in nickel steel, and it was therefore thought probable that the slag particles might be some nickel silicate, and considerable effort was given to discover whether the slag particles contained nickel or not. Some slag particles were picked out of the fracture, under the microscope, by means of a fine needle, dissolved in HF or fused with Na_2CO_3, and a concentrated drop of the final solution tested with diphenylglyoxime, which gives a very sharp test for minute quantities of nickel, but no sign of nickel could be found.

In the expectation that at least some of the slag particles present in the steel would not go in solution, about 20 g. of a flaky bar was dissolved in 1:3 HCl on the hot bath and the residue filtered. It was found in several trials that the precipitate on the filter consisted of small distinct slag particles together with flocculent silica and MnO_2 and it was difficult to separate these masses. For separation a small flotation apparatus of glass tubing was blown and tried with some advantage, but the best method was to brush the dried filter with a fine brush whereby the larger slag particles could be taken off. Alundum crucibles for filtering also served the purpose well. Filtering on "ashless" filter, burning it and trying to determine the residue under the mineralogical microscope was not successful because the ashless filter contained too many crystalline substances. Good silk filters were much better, and with them it was found under the mineralogical microscope that the slag particles were of a glassy nature. Fig. 15 shows the slag particles found in 20 g. of steel. Testing for nickel with this larger mass gave no indication. But it was found that fusion with KNO_3 and Na_2CO_3 gave a strong reaction for Mn and it was also found that iron and SiO_2 were present. A test showing presence of calcium in concentrated solution might be mentioned, but it is possible that the glass flask was dissolved, and there has been no time to check this result.

These tests show at least some of the inclusions to be manganese silicates, which only confirms the work of others and the more important fact that no nickel-silicate is present. It is clear that on dissolving steel in acid, inclusions like MnS or very limy silicates will go into solution, and the pressure of such slag particles in the fracture can only be proved directly under the microscope or by the tedious and difficult method of picking them out and analyzing them microchemically.

Importance of Slag Inclusions

It was concluded that in the test bars from party A the slag inclusions played an important rôle in causing low physical tests, but it was, of course, of interest to find whether the same source for the trouble could be found in test bars from other concerns.



FIGS. 10 TO 15

Fig. 10. Accepted bar with cup fracture, from party A. HNO_3 etching. × 300. Fig. 11. Rejected bar, with irregular fracture, from party A. HNO_3 etching. × 300. Fig. 12. Rejected bar with fibrous fracture, from party A. HNO_3 etching. × 300. Fig. 13. Accepted bar with cup fracture, from party A. HNO_3 etching. × 100. Fig. 14. Rejected bar with irregular fracture, from party A. HNO_3 etching. × 200. Fig. 15. Iron and manganese silicate slag particles remaining after solution of 20g. nickel steel, from party A. × 20.

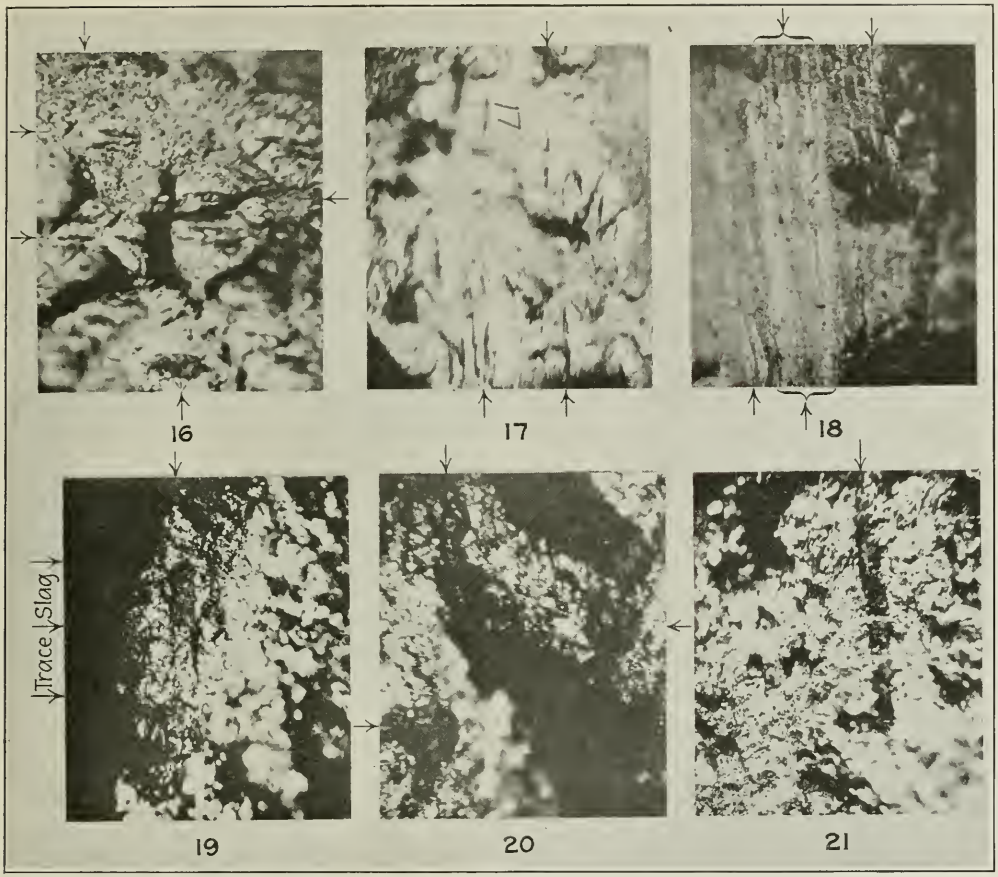
TABLE I—DESCRIPTION OF NICKEL STEEL TEST BARS FROM PARTY B

Test Bar Mark	Physical Properties: Elastic Limit	Ultimate Strength	Elongation	Reduction in Area	Analysis: C	Mn	Si	S	P	Ni	Cr	Description of Fracture
720 B20	71,000	108,000	10 5	13.3								Very many dark green inclusions in bright spots.
720 MT2M	58,000	95,000	15 0	20 2								Very many dark green inclusions in bright spots.
218 TD	73,000	100,500	15.0	21.6								Very many inclusions in ¼ of fracture, light green in color.
293 T1B1	77,000	108,500	10 5	17.0	0 47	0 60	0 14	0 025	0 039	3 26		Very many dark green inclusions in bright spots.
773 BT3O	75,000	106,500	15.0	16 2	0 31	0 55	0 09	0 021	0 032	2 90	0 27	Very many inclusions in bright spots. Some big yellow inclusions; also traces. Inclined fracture.
947 BT2M	70,000	106,000	14 0	20 5	0 33	0 59	0 09	0 026	0 028	2 63	0 13	Very many yellow inclusions in bright spots. Many traces. Many dark and yellow inclusions.
847 MT3M	69,000	107,000	15 0	22 3								
864 BT1	68,000	105,500	13 5	34.0	0 40	0 53	0 14	0 030	0 020	2 85	0 21	Many dark and yellow inclusions in bright spots.
218 B	68,000	99,000	6 0	2.7	0 36	0 62	0 11	0 027	0 032	3 25		Many dark and yellow inclusions in bright spots. Bad fracture.
815 BT2M	65,000	92,000	8 0	4.8								Many yellow inclusions in small bright spots and some dark green inclusions in larger bright spots.
864 MT1M	64,000	104,400	17 0	28.0	0 40	0 53	0 14	0 030	0 020	2 85	0 21	Many yellow inclusions in bright spots. Traces.
848 MT1M	62,000	91,500	12 0	30.8	0 33	0 59	0 09	0 026	0 028	2 63	0 13	Many thin inclusions, yellowish, green and dark, mostly in bright spots
783 BT1M	66,000	98,000	17.5	33.4	0 38	0 58	0.09	0 036	0 018	2 29	0 16	Many thin, dark inclusions. A few yellow inclusions in bright spots.
783 MT1M	67,000	107,000	16 0	21.7								Many yellow inclusions. Many traces in bright spots Fracture inclined.
823 MT1M	87,000	115,500	10 0	13.3	0 36	0 65	0 10	0 029	0 026	2 89	0 30	Many inclusions, some large and green. Traces in bright spots.
824 BT1I	85,000	110,500	12.0	28.5	0 33	0 53	0 10	0 026	0 018	2 60	0 16	Many inclusions in bright spots. A large green inclusion. Several traces.
848 BT2M	62,000	95,000	20 5	32.1	0 33	0 59	0 09	0 026	0 028	2 63	0 13	Several small dark inclusions in bright spots.
873 BT1O	68,000	102,500	18 0	30.8	0 32	0 57	0 13	0.013	0.031	2 89	0 06	Several green inclusions in bright spots; also traces inclined fracture.
823 MT2M	92,000	117,000	16 0	38.5	0 36	0 65	0 10	0 029	0 026	2 89	0 30	Several inclusions in bright spots. Traces.
773 BT1O	70,000	100,500	19.5	34 7	0 31	0 53	0 09	0 021	0 052	2 90	0 27	Several small green inclusions in center of fracture.
817 BT2I	103,000	125,000	15 2	40 3	0 34	0 54	0 18	0 026	0 021	2 52	0 25	Several yellow inclusions, many traces, mostly in center of fracture.
861 BT2I	80,000	106,000	16 5	34 7	0 39	0 64	0 13	0 017	0 021	2 55	0 15	Several yellow inclusions, many traces.
783 MT4M	60,000	101,500	15 5	25 7	0 38	0 58	0.09	0 036	0 018	2 29	0 16	Some slag particles; many traces.
864 MT2	66,300	103,300	19 5	37.3	0 40	0 53	0 14	0 030	0 020	2 85	0 21	Some small yellow inclusions in bright spots in center of fracture.
864 BT2M	67,000	105,500	16 5	40.9								Some small inclusions; several traces in bright spots.
819 MT2M	80,000	111,500	18 0	46.3	0 38	0 55	0 07	0 021	0 018	2 58	0 25	Some yellow inclusions and several traces in center of fracture.
815 BT1M	66,000	106,400	15 0	29.0								Some big yellow inclusions and several small inclusions in bright spots.
218 TM7A	80,000	106,000	20 5	44 8	0 36	0 62	0 11	0 027	0 032	3 25		Some small dark inclusions and traces. Old fracture.
259 BT5M	83,000	106,000	19 0	45 3	0 40	0 70	0 10	0 030	0 035	3 10		Some dark and yellow inclusions. Several traces. Fracture inclined.
783 MT1M	90,000	116,000	19 0	40 3	0 38	0 55	0 09	0 026	0 027	2 76	0 22	Some small yellow inclusions; several small traces.
861 BT1M	76,000	106,000	18 1	44 6	0 39	0 64	0 13	0 017	0 021	2 55	0 15	Some yellow inclusions. Several traces, some of them large.
783 MT2M	67,000	110,500	18 0	37.2	0 38	0 58	0 09	0 036	0 018	2 29	0 16	A few small yellow inclusions. Old fracture.
815 BT3M	66,000	106,500	16 5	42 7	0 40	0 55	0 12	0 027	0 020	2 64	0 32	A few small inclusions and a few traces in bright spots.
819 BT2M	83,000	110,500	24 5	49.1	0 38	0 55	0 07	0 021	0 018	2 58	0 25	A few yellow inclusions and some traces in center of fracture.
780 BT2M	68,000	95,500	20 0	46.3	0 32	0 50	0 07	0 021	0 024	2 52	0 17	A few yellow inclusions and several traces.
831 BT1I	85,000	100,500	19 0	47.7	0 37	0 57	0.10	0 025	0 023	2 88	0 25	A few small gray inclusions in white spots and a few traces.
850 MT1I	85,000	111,000	19 5	46.3	0 40	0 56	0 11	0 030	0 020	2 82	0 13	One small dark inclusion. Thin traces.
825 MT1I	93,000	115,500	21 0	49.1	0 35	0 57	0.13	0.015	0 015	3 30	0 15	One small yellow inclusion. A few traces.
840 MT1	84,000	113,000	18 2	50 5	0 38	0 50	0 07	0 017	0 026	2 70	0 11	One small black spot. A few traces.
819 MT1M	88,000	113,000	18 0	49.1	0 38	0 55	0 07	0 021	0 018	2 58	0 25	One small yellow inclusion. A few traces.
817 T1M	86,000	115,500	18 5	46 3	0 34	0 54	0 18	0 026	0 021	2 52	0 25	Several traces and possibly some yellow slag.
815 MT3M	69,000	115,500	18 5	41 8	0 40	0 55	0 12	0 027	0 020	2 64	0 32	Fair but old fracture. Possibly a few traces.
864 MT2M	66,300	103,300	19 5	37.3	0.40	0 53	0 14	0 030	0.020	2 85	0 21	A few traces in a bright spot. Inclined fracture.
266 T1F	58,000	65,000	23 0	40.3	0.50	0 63	0 21	0 021	0.036	3 40		No inclusions. Some small traces.
796 MT1M	85,000	111,500	19 0	49 1	0 39	0 55	0 11	0 020	0 021	2 86	0.10	Small traces.
846 MT2I	74,000	102,500	19 5	55.9	0 37	0 58	0 11	0 029	0 020	2 61		Some small traces. Good fracture.
826 MT4M	92,000	117,000	17 0	43.3	0.35	0 57	0 13	0 045	0 015	3 30	0 15	Some deep traces. Fracture inclined.
846 MT1I	76,000	105,500	20 0	54 6	0 37	0 58	0 11	0 029	0.020	2 61		No inclusions. A few small traces.
873 BT6M	63,000	94,000	16 5	38 8	....							Two or three small bright spots.
930 MT1M	64,000	97,000	23 0	53 3	..							Two or three small bright spots with dots of slag.
919 BT1M	72,000	105,500	21 0	49.1								Two or three small bright spots.
888 MT1M	91,000	116,500	19 0	46 3								A few small traces.
804 B1M	87,000	108,500	20 0	51 9								A few small traces.
887 BT2M	61,000	98,000	22 0	47 7								One small green inclusion.
881 MT3M	69,000	105,500	23 0	53 5								One small green inclusion.
931 BT2I	76,000	108,500	19 0	50 5	..							A trace.
927 MT2M	73,000	105,500	21.0	46 3								No inclusions.
922 MT1M	75,000	107,000	23.0	55 9								No inclusions.
895 MT6M	68,000	99,500	24 0	57.3								No inclusions.
217 BTL	77,000	103,000	19 5	59 8								No inclusions. Good but old fracture.
218 BR	72,000	103,000	24 0	57 3	0.36	0 62	0 11	0 027	0 032	3 25		No inclusions. Good but old fracture.
217 B11	77,000	103,000	19 5	59.8								No inclusions. Good star fracture, but old.

The opportunity was given to examine with the binocular microscope numerous freshly broken samples from party B. Examination was done in the following manner: Test specimens were taken serially as they were placed in the rack, their numbers noted, and the fractures examined with different magnifications. Corresponding remarks were jotted down describing as briefly as possible the general characteristics of the fracture, giving an idea of the number, color, and mode of occurrence of the slag particles. In some of the fractures some shining streaks called "traces" were also noticed, probably matrices from which slag had fallen; this could sometimes, but not always, be ascertained.

When this listing was finished the samples were then grouped according to the number of slag inclusions and the physical data were added (Table I). Study of this will show that there is a striking general connection between the number of slag inclusions and the elongation and contraction; but the elastic limit or tensile strength seems not to be affected.

Great pains was taken in the examination of the fractures of test bars with the binocular microscope, whereby a first approximate quantitative proof can be given of the influence of the slag inclusions on the physical qualities of steels with practically the same heat treatment, and particularly on the elongation and



FIGS. 16 TO 21. SLAG INCLUSIONS IN DEFECTIVE FRACTURES, BOTH NICKEL AND CARBON STEELS

Fig. 16. Lenticular slag inclusions in 823MT1M, from party B. × 20. Fig. 17. Lenticular slag inclusions in 847BT2M, from party B. × 20. Fig. 18. "Traces" or cavities from which slag has fallen, from party C. × 20. Fig. 19. Large slag inclusion in sample 4 from party D, with "trace" extending to right. × 20. Fig. 20. Round slag exposures in longitudinal test of carbon steel 210P from party F. × 55. Fig. 21. Streak of slag in transverse test of carbon steel 55G1, from party F. × 15.

contraction. It is most striking to find that in all good test bars examined either no slag particles or only very small round particles or traces of them are found.

It must, however, be taken into consideration that there is some variation in the mechanical tests because of variation in chemical composition and heat treatment, which latter is supposed to be practically constant, but is subject to the influence of shop conditions. The effect of different heat treatments, however, is practically excluded in six tests from the same forging (No. 843*), showing that the results differ both in breech end and muzzle end corresponding with the number of slag inclusions. The typical fracture of the poor bars of Table I is shown in Fig. 1, and photographs of the slag inclusions taken with the binocular microscope are shown at 20 magnifications in Figs. 16 and 17. A similar photograph of flaky fractures of bars from party C are shown in Fig. 18 and from party D in Fig. 19. No data on the bars from F were available. These photographs cannot, of course, all be in focus, as the fractures are too irregular. It is important to note the importance of good illumination for the microscopic examination. Sometimes diffused sunlight, at other times a strong daylight lamp is the best, depending on the color of the slag. As high a magnification as 80 is ordinarily necessary, but it sometimes happens that the slag can be seen with the naked eye.

*Analysis: C..... 0.40 per cent; Mn..... 0.63 per cent; Si..... 0.10 per cent; S..... 0.035 per cent; P..... 0.031 per cent; Ni..... 2.88 per cent; Cr..... 0.30 per cent

Micrographic Examination

The microstructure of some of the bars in Table I was examined carefully. We could suspect the banded structure of the light and dark sorbite with Widmanstättian lines shown in Figs. 22 and 23 to be the cause of the poor result of test bar 720 BT2O, but we find a similar structure in the good bar 873 BT6M (Figs. 24 and 25) and less distinctly in 895 MT6M, both of which have a good cup fracture. The microstructure in Fig. 26 of Sample No. 107, with the rather surprising physical test of elastic limit 80,000, tensile strength 95,500, elongation 23 per cent, reduction in area 69

per cent, showing ferrite and pearlite banding, will give an explanation as to the origin of sorbite banding; it is simply that the heat treatment has not brought the solid solution to a condition of homogeneity.

Fractures of some nickel steel test bars from party D were now examined and the results given in Table III. The "flakes" in these fractures (shown in Fig. 2) are larger and more coarsely crystalline, with a leafy aspect instead of with a radiating fine grain as most of those in Table I. Some of the worst fractures can hardly be explained by the small amount of slag inclusions, as can be seen from a study of the table. The microstructure of D6 at the intersection between the flake and a plane meeting at a blunt angle (such as in Fig. 9) shows fine uniform sorbite, and a very small patch of Widmanstättian structure was all that could be found, this occurring at some distance back of the intersection. Evidently Widmanstättian structure could not have caused the flake in this case.

Internal Cracks

With but little slag in the fracture and no abnormalities in the microscopic appearance, the cause of these defective fractures remained undecided until more nickel steel bars from party E were obtained. These are listed in Table IV. The fracture of bar No. 681 shows a crystalline "snowflake," and No. 230 a crystalline fracture coated with oxide, evidently formed in a crack in the steel, probably in the heat-treating furnace or during forging. The microstructure of 681 (cut at a slight angle with the flake) is shown in Fig. 27, the microstructure of 230 (cut perpendicularly to flake) in

TABLE II—TABULATION OF CHARACTERISTICS OF FRACTURES FROM FORGING 843

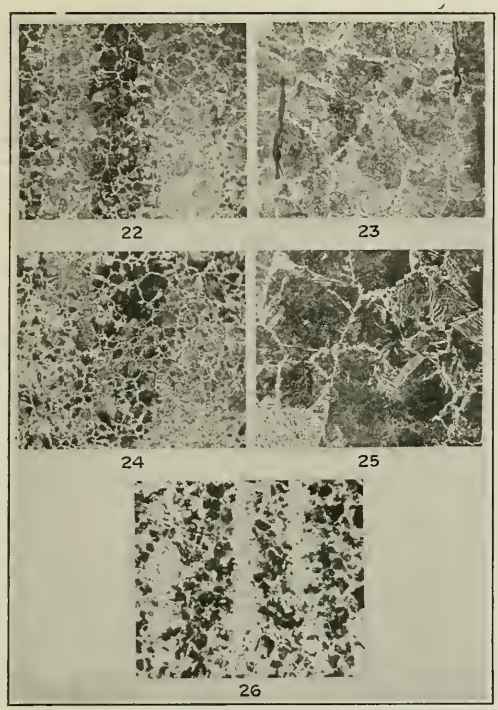
Test Bar Mark	Physical Properties: Elastic Limit	Ultimate Strength	Elongation	Reduction in Area	Analysis: C	Mn	Si	S	P	Ni	Cr	Description of Fracture
843 MT2M	75,000	107,000	13.0	22.3	0.40	0.63	0.10	0.035	0.031	2.88	0.30	Many inclusions, some large and yellow. Traces.
843 BT1M	69,500	103,900	18.0	35.3								Many very small dark inclusions in small bright spots.
843 MT4M	71,000	105,000	11.0	5.8								A big bright spot with dark inclusions. One very big dark slag spot outside this. Several traces.
843 MT5M	70,000	107,500	21.0	47.7								One yellow inclusion in bright spot. Good fracture.
843 BT4M	66,000	99,500	22.0	51.9								A trace. Good fracture. A few small traces. Good fracture.
843 MT3M	69,000	103,000	22.5	50.5								

TABLE III—TEST BARS FROM PARTY D

Test Bar Mark	Physical Properties: Elastic Limit	Ultimate Strength	Elongation	Reduction in Area	Analysis: C	Mn	Si	S	P	Ni	Cr	Description of Fracture
1	58,000	89,600	0.0	0.0	0.39	0.49	0.13	0.018	0.009	3.01	0.24	A small bright spot with dark green slag inclusion.
2	71,000	90,700	0.0	0.0								Outside of spot are large and many small traces. One-tenth area a bright spot with a dark green slag inclusion. Outside this the fracture is laminated and has slag streaks and many shining white traces.
3	59,000	76,500	0 0	0 0	0 39	0.63	0.21	0.012	0 016	2 77	0 39	Three bright shining crystalline spots without inclusions. A few yellow particles found in remaining half of fracture.
4	58,000	97,250	10 0	0 0	0 30	0 55	0 22	0 024	0 018	2 90	0.42	Angle fracture. Small bright spot on one side with a large green inclusion. A few slag particles outside spot.
5	56,000	65,000	0 0	0 0								One-third area a shining bright spot, coarsely crystalline, with no slag. Several large traces outside spot.
6	57,000	67,550	0 0	0 0								Two-thirds area a bright spot without inclusions. A few small traces of slag outside spot.

TABLE IV—NICKEL STEEL BARS FROM PARTY E

Test Bar Mark	Physical Properties: Elastic Limit	Ultimate Strength	Elongation	Reduction in Area	Analysis: C	Mn	Si	S	P	Ni	Cr	Description of Fracture
230 MT3I	47,000	47,030	0 0	0.0	0 38	0 69	0 24	0 033	0 043	3 25	. . .	Irregular fracture mostly covered with coat of scale. Bright part is crystalline with some slag streaks
681 BT1M	45,000	45,250	0 0	0 0	0.40	0 58	0 17	0 029	0 054	3 00	.	Four-fifths of surface is an irregular coarse crystalline bright spot with a few large patches of green slag inclusions. Smaller slag streaks along edge of flake.
564 BT1M	60,000	69,000	2.5	3 0	0.42	0 70	0 27	0 030	0 045	2.75	.	One-third of fracture irregularly coarse crystalline with a large patch of light green slag. No inclusions found in rest of fracture, which is fine crystalline.
632 MT1M	72,000	93,750	6 0	7.0	0.38	0 68	0.16	0.030	0.047	3.04		Three small bright coarse-crystalline spots. Streaks of slag and laminations near spots. Balance of fracture fine crystalline with no inclusions.
5512 BT1I	62,000	100,600	14.0	19 1	0.36	0.53	0 20	0 029	0.046	3 00	. .	Half of fracture is bright spot, irregularly coarse-crystalline in center, surrounded by porous area with a few small dark slag streaks. Balance of fracture fine crystalline and slag-free.
5943 BT1I	61,000	94,500	10.5	16 6	0 40	0 57	0 22	0 030	0 046	3.22	. .	One-fifth area a bright spot whose center is coarsely crystalline and white. Radiating structure from here to adjoining angular fracture. No inclusions.



FIGS. 22 TO 26.

Fig. 22. Banded sorbite in defective bar 720 BT2O, from party B. HNO_3 etching. × 25. Fig. 23. Same as Fig. 22. × 100. Fig. 24. Banded sorbite in accepted bar 872 BT6M, from party B. HNO_3 etching. × 25. Fig. 25. Same as Fig. 24. × 100. Fig. 26. Non-homogeneity in 107 from party B. HNO_3 etching. × 50.

Fig. 28, the latter showing a crack in a fine sorbite-structure and with no slag; a nearby crack, however, passed through small slag particles.

It seemed possible, therefore, that the cause of these flakes could be the cracking or incipient cracking of the steel previous to testing. To further illustrate this question a cold-broken part of a gun-tubing from party C shown in Fig. 29 was examined. Round coarse-crystalline "snowflakes" are here found separated by fibrous structure. Transverse (a — a) and longitudinal (b — b) sections of this broken part were polished and etched with the Stead-Le Chatelier reagent, and are shown in Figs. 30 and 31. There is no difference in the microstructure near the snowflakes and near the fibers, nor did the microstructure show any difference. In the longitudinal section (Fig. 31) it can be plainly seen how the dendrites run straight across the crater of a "snowflake." On its side the crater showed evident shearing.

Etching this tube a long time in strong acid revealed deep seated, fine cracks, running approximately radially and in the direction of the forging. Microscopic examinations of this sample as well as of samples 3 and 6 from party D and 681 from party E show no relation between the grain-size of the flaky fracture and the ferrite network of the microstructure. In sample 6 there is hardly any network visible, and 230 has none at all (Fig. 28). Where ferrite network was found, the grains exhibited in the fracture were much coarser than those in the crystalline network, so the crack or fracture must have gone through two or more crystals, irrespective of grain boundaries.

It is known that acid etching of forgings very often reveals deep cracks which may cause flakes; but often flaky test bars are found in sections where no cracks are found on etching. It is of interest to find whether a difference in structure would be the cause for the etching cracks. The author has made a few tests on deep etching for cracks which was done after the specimens had been carefully polished and lightly etched for development of microstructure. He has not found, so far, that the acid produces cracks where none were found in the microstructure. Where slag particles were situated, however, the acid generally left deeper etching pits, which is natural, because the acid gets a larger surface to attack after the acid has dissolved the slag, either directly or by dissolving the material around it. It seems, therefore, reasonable to assume that the cracks noted in the examination of flaky bars are present in the forging; they may have been original cracks in the ingot, or may have been formed in the subsequent heating and forging.

Kilby[1] has shown that improper pouring or pouring at too high or too low temperatures will cause cracking in the ingot. But there has been an endless discussion about the influence of the mold on the cracking and about which form of mold best will prevent cracking. To the author the main reason for cracking seems clear, considering the fact on which Driessen[2] has given numerical data, that steel, cooling and contracting from high temperature, has a period of expansion corresponding to the transition range. When the ingot cools, the outside layers will have expanded while the inner is still hot, and be less ductile when the interior layers expand, whereby the surface may start to crack. The author has noticed such cracking proceeding several days after the casting of large ingots. It is natural that it should start where the outer cold skin is the thinnest—for instance in the grooves of fluted ingots and in the sides of squares and polygons. On the other hand, the columnar structure of the surface layers might induce cracks leading in from the corners, because the weakest planes are to be found where the columns from different directions intersect, and where we also find most of the segregated impurities. Surface cracks must, however, be coated with oxides and are not the same as cracks in the inner parts of the steel, which on fracture are perfectly shiny and crystalline. Such cracks must have been formed by improper heating or forging whereby the surface has been stretched more than the inside can follow, or they may have their origin in blowholes which are not completely welded.

Blowholes and Forging Flaws

A sample of such unwelded blowhole in a fractured test piece is shown in Fig. 9, where the smooth shining surface of the flake leaves no doubt as to its nature. The polished section cut through the blowhole did not show any difference in microstructure of the flake and the material back of it, all being sorbitic. That blowholes do not necessarily weld at high temperatures can easily be shown by "forging" molding wax in which holes are made.

It is an absolute necessity that the surfaces touch

[1] *Journal*, Iron & Steel Institute, 1917, Vol. II, p. 69; *Engineering*, 1918, p. 34.

[2] *Ferrum*, Vol. II, p. 129.

when they are to be welded, and holes do not close before a certain reduction is performed. The temperature must, besides, be sufficiently high for welding, as shown by Stead[3].

A sample from soft steel used in a demonstration of improper hot forging practice was kindly furnished the author by J. S. Taylor of the Carnegie Institute of Technology and is shown in Figs. 32 and 33. The cracks have their principal direction radially, which is natural since the strain that has produced them goes at right angles to the direction of blows of the hammer or press when flat dies are used. It is clear that slag inclusions when forged will help to start such cracks, because they leave sharp angles in the strained material.

Flakes in Carbon Steels

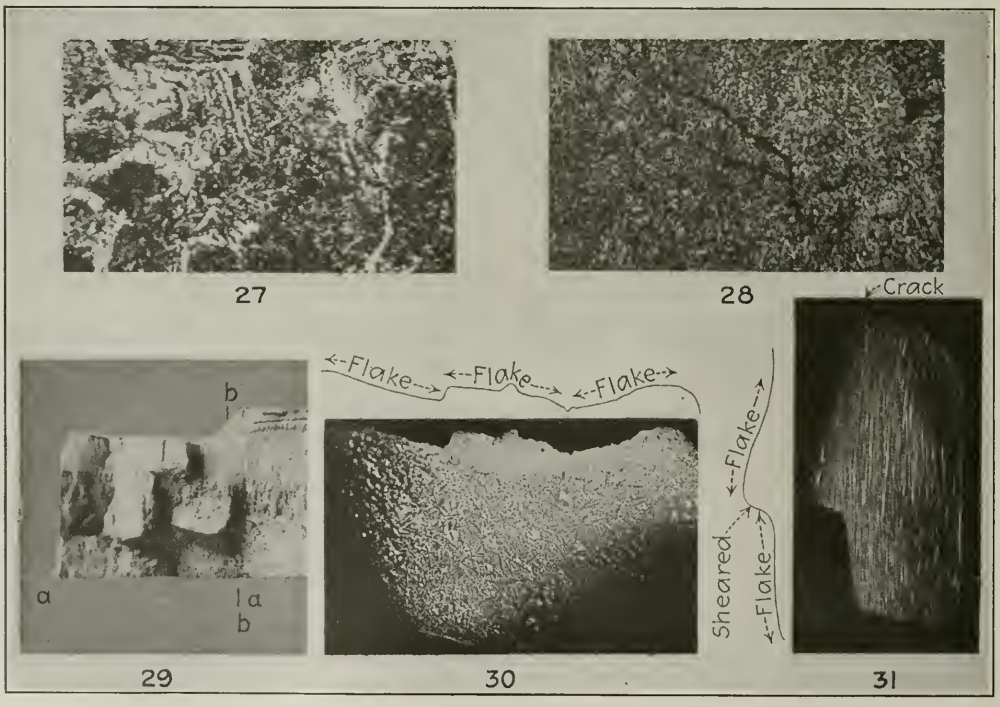
In the examination so far made on nickel steels, I have practically always found slag inclusions associated with the flakes. It was considered probable that such inclusions would have the same effect on ordinary carbon steels, where the more scant occurrence of flakes must partly be ascribed to the fact that test bars are more generally longitudinal and seldom transverse for these types of steel. The larger section of a slag particle flattened in the direction of work and the sharp angle it cuts in the steel matrix must naturally show a greater effect in the results of testing transverse pieces.

With the interested help of party F, such transverse tests were made of different carbon steels with some corresponding longitudinal tests, and the results given in Tables V and VI. The flakes in these bars are more variable and are shown in Figs. 4 to 9 inclusive. The flaky test pieces showing the poorest physical properties are those containing large masses of slag (No. 210 P and 55), the slag showing up as round spots in the longitudinal tests (Fig. 20) and as streaks in the transverse (Fig. 21). The microstructures (Figs. 34 and 35) of cuts transversely and longitudinally through a fibrous flake show how the slag is arranged in light-colored streaks following the fibers. Fig. 36 gives microstructure containing many slag inclusions found near the peculiar spherical crater in 3070 (Fig. 7). The tests of greatest interest in Table VI are, perhaps, those of the two bars marked 3872 F, cut from adjacent parts of the forging, one giving a good test and the other a rotted fracture, breaking under the head along a crack which was declared by party F to be caused by cracking in quenching. Examination of these fractures shown in Figs. 5 and 6 revealed the presence of dark iridescent inclusions, and a microphotograph of the fracture-edge (Fig. 37) shows a decarbonized area filled with holes from which MnS had been dissolved by sodium-picrate[4].

We have exhibited in Table VI the effects of another variant of flake illustrated in Fig. 4 and characterized by a smooth round shining silky spot not connected

[3] *Journal*, Iron & Steel Institute, 1911 and 1912.

[4] After Comstock's method; *Journal*, Iron & Steel Institute, 1916.



FIGS. 27 TO 31

Fig. 27. Bar 681 from party E, slightly inclined to crystalline "snowflake." HNO_3 etching. × 300. Fig. 28. Bar 230 from party E, perpendicular to oxidized spot in fracture. HNO_3 etching. × 300. Fig. 29. Fractured gun tube from party C. Three flakes intersect the surface between *a* and *a*, while a fourth is at the center at section *b-b*. Natural size. Fig. 30. Surface *a-a* with copper deposit. × 1.5. Fig. 31. Surface *b-b* with copper deposit. × 1.5

TABLE V—TRANSVERSE TESTS OF CARBON STEEL BARS FROM PARTY F

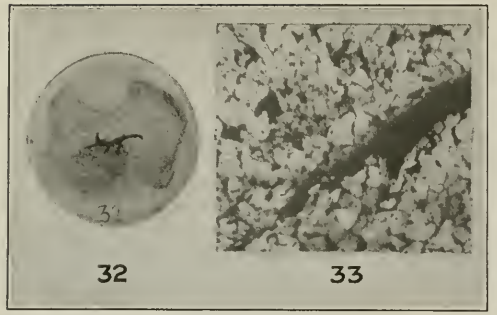
Test Bar Mark	Physical Properties: Elastic Limit	Ultimate Strength	Elongation	Reduction in Area	Analysis: C	Mn	Si	S	P	Ni	Cr	Description of Fracture
B1	42,430	71,900	23 5	46 3	0 25	..	....	.. ..	....	..	....	Annealed. Scattered dots of greenish and dark slag.
A1	35,190	68,400	27 0	41 9	0.25	...	...	... ...	...	...	....	Annealed. Some small traces and dark dots.
B2	36,440	68,640	26 0	40 4	0 25	...	...	... ...	...	...	...	Annealed. A few small greenish inclusions in bright spots.
A2	44,930	68,640	21 5	27 5	0 25	.	....	. .	.	. .	...	Annealed. Many small yellowish and one very big brownish inclusion.
55 GA1	36,940	61,900	14 0	18 8								A mass of small yellowish green inclusions and many large brownish inclusions.
55 GB1	37,440	62,160	12 5	18 8	0 23	0 45	0 17	0.033	0 053	..	. .	Same as 55 GA1.
55 AA1	41,930	60,400	21 0	29 9								Annealed. A mass of green slag inclusions.
55 AB1	26,960	60,660	19 0	29 5								Same as 55 AA1.
A 5050	51,420	87,120	13.0	20 6								Very many inclusions; small green; a few dark or light. Occur as streaks in laminated part and as dots and short streaks in crystalline part of fracture.
T 1-5050	51,920	82,880	23 0	37.7	0 38	0 56	0 20	0.028	0 045	. .	. . .	Quenched at 1550, drawn at 1220. Several short shiny streaks and small traces.
T 2-5050	50,520	83,620	20.5	34 3								Quenched at 1550, drawn at 1220. Several small dark inclusions.
R1X	64,400	82,620	18 5	27 5								Quenched at 1550, drawn at 1250. Tenth of area is fibrous flake with several yellow inclusions. Balance crystalline with two or three slag particles.
R 2X	68,900	87,120	25 0	37 3	0 44	0 71	0.20	0 041	0 048	.		Some scattered traces.
R1Y	63,650	81,520	20 5	22 4								Quenched at 1550, drawn at 1250. Half area is fibrous flake with many greenish inclusions. None in crystalline part of fracture.
R 2Y	70,680	85,720	22.5	38 8	0 45	0 61	0.23	0.032	0.049	....	.. .	Some small greenish inclusions, several scattered small dark dots.

TABLE VI—LONGITUDINAL TESTS OF CARBON STEEL BARS FROM PARTY F

Test Bar Mark	Physical Properties: Elastic Limit	Ultimate Strength	Elongation	Reduction in Area	Analysis: C	Mn	Si	S	P	Description of Fracture
199 P	36,240	67,640	28 0	36 4	0 27	0 52	0 20	0 032	0 052	Annealed. A few light green inclusions in bright spots. Small dark spots scattered over surface.
202 P	36,840	69,050	27.5	33.5	0.26	0.48	0.20	0.033	0.047	Annealed, two or three round yellow inclusions. Small dark spots scattered over surface.
210 P	35,940	66,560	33 0	48 5	0 26	0 46	0.17	0 030	0 051	Annealed. Some large, round, yellow inclusions in bright spots and small holes between.
3872 F	51,580	73,980	0 0	0 0	0 45	0 76	0 23	0 032	0 048	Annealed. Irregularly cracked fracture with bluish dark inclusions along crack.
3872 FF	53,160	82,620	27 0	50 6						Small scattered holes and two or three small bright spots. No inclusions.
234I	36,420	67,060	10.5	19 9	0 28	0 42	0 14	0 036	0 054	Annealed. A smooth, velvety bright spot. Small scattered dark inclusions.
234II	33,220	64,660	12.5	32 0						A smooth, velvety bright spot.
3070 D	59,460	91,880	16.0	27 5	0 44	0 71	0 22	0 032	0.047	Water quenched and drawn. A spherical flaw, crystalline in center, dark irregularities on sides; perhaps dots of MnS.
M 53D	....	....	..	....	0 47	0 71	0 18	0 034	0 043	Heated in 11 hrs. to 1500; held 8 hrs.; heated in 2 hrs.; to 1600; held 2 hrs.; quenched in water; drawn to 1250 in 8 hr., held 6 hrs.; air cooled. Fracture showed angular flow, smooth and shining; probably side of an unwelded blowhole.

TABLE VII—CARBON STEEL BARS FROM PARTY G

Test Bar Mark	Physical Properties: Elastic Limit	Ultimate Strength	Elongation	Reduction in Area	Analysis: C	Mn	Si	S	P	Description of Fracture
1642-2	48,050	83,000	19 5	17 8	0 47	0 59	0 20	0 033	0 046	Whole fracture fibrous. Some dusty, thin, dark inclusions. Many traces.
1642-4	50,970	89,400	19 0	20 3						Whole fracture fibrous. Some thin dark streaks. Many traces.
2536-2	54,700	100,700	10 0	10 1						Three-fifths fracture fibrous with many shining dark slag streaks.
2536-3	53,280	96,140	10 0	10 0	0 50	0 55	0 26	0 052	0 035	Half fracture fibrous with many shining dark inclusions. A few small inclusions in crystalline part.
2536-4	55,260	101,900	12 0	13.4						Half fracture fibrous with many dark slag streaks.
2649-4	52,060	102,500	14 0	14 2						Half fracture fibrous with shining dark slag streaks.
2808-3	54,000	90,800	5.0	4 3	0 55	0 58	0 22	0 046	0.036	Third fracture fibrous with many dark shining slag streaks.
2856-2	50,330	93,760	20 5	25 9	0 46	0 68	0 24	0 037	0 039	Fracture irregularly fibrous, short dark streaky inclusions.
2856-3	50,880	96,700	17.5	28 9						Fracture irregularly fibrous, thin dark slag streaks.
2788-2	43,860	82,200	22.5	32 3						Fracture slightly fibrous. Some traces.
2788-3	44,230	85,000	19 5	24 9	0 55	0 58	0 22	0 050	0.036	Fracture fibrous. Some streaks of slag.
2788-4	49,060	87,400	17.5	26 2						Irregularly fibrous with small slag streaks.
2618-2	53,940	105,200	14.0	16 0	0 57	0 61	0 24	0 048	0 042	One-fifth fracture fibrous. Larger patches of shining slag.
2393-2	43,550	80,500	13.5	19.8						Laminated fracture. Large and small dusty steel gray inclusions.
2393-3	43,880	81,400	8 0	12 0	0 55	0 61	0 26	0 052	0 035	Half laminated fracture containing dusty steel gray inclusions.
2399-2	53,880	60,500	0 0	2 0						Bad fibrous flake. Irregular fracture.
2164-2	59,200	107,950	17.5	34 7						No lamination. Very short, dark traces at angle with fracture.
2164-3	63,050	107,700	7 0	6 3	0 52	0 52	0 22	0 047	0 034	One-tenth fibrous, filled with shining traces and dark slag streaks.
2164-43	62,050	105,400	7.0	8.4						One-fifth area at edge laminated, containing shining irregular traces and many thin dark inclusions.
2301-2	52,720	97,700	14 1	16.5						Half laminated. Traces, a dark slag streak, and some green inclusions.
2301-3	51,950	98,100	16 5	19 2	0 52	0 70	0 22	0 047	0 030	One-third fibrous. Shining traces and some tiny inclusions.
2301-4	53,200	100,950	17.0	26 8						Two-thirds fibrous. Shining traces and some slag streaks.

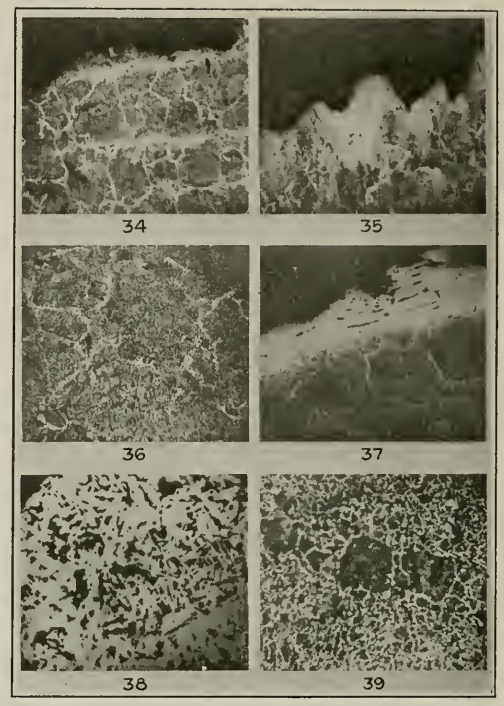


FIGS. 32 AND 33

Fig. 32. Improper forging opens internal cavity. Heyn's reagent. Natural size. Fig. 33. Same as Fig. 32. HNO_3 etching. × 100.

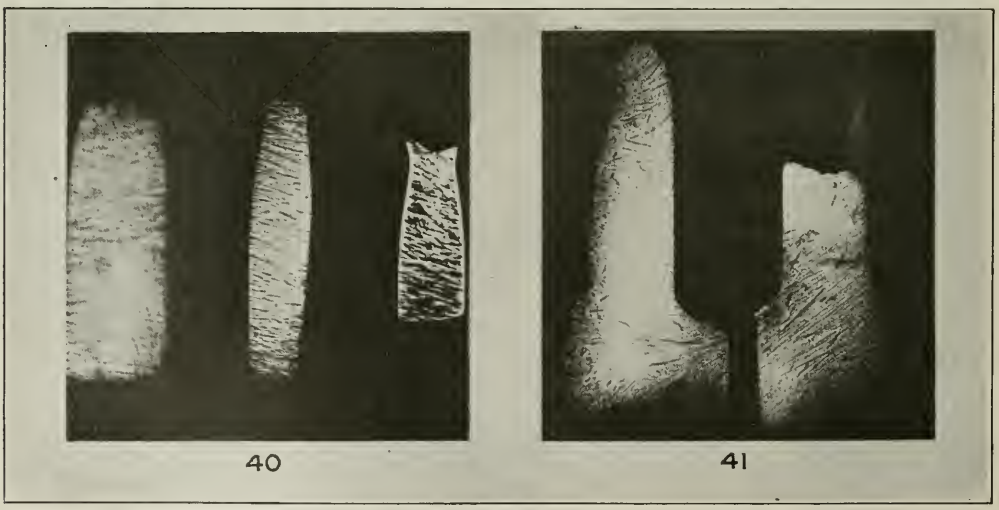
with large slag particles, but where possibly small dots of MnS are present. On cutting through this spot and examining the microstructure of the bright edge a somewhat heavier line of ferrite was found to accompany the fracture. Fig. 38 shows this structure a little back of the flake, giving the distribution of smaller grains within the larger primary crystal, which nearly outlines the picture and which is caused by heating to high temperatures.

Examination of transverse bars of higher carbon content from party G are given in Table VII. All the flakes here are of the fibrous type (Fig. 3). The slag inclusions—nearly all glossy, dark streaks—are almost exclusively in the fibrous part of the fracture. They are, as a rule, very thin, but where they are easily distinguishable the physical tests are lower. There is one peculiarity in these tests, namely, that in tests where only part of the fracture is fibrous, the elastic limit and tensile strength are higher, but the elongation and reduction in area are lower than in fractures where it is entirely fibrous, which may be explained



FIGS. 34 TO 39

Fig. 34. Transverse section of fibrous flake in sample A1 from party F. HNO_3 etching. × 50. Fig. 35. Longitudinal section of fibrous flake in sample A1 from party F. HNO_3 etching. × 50. Fig. 36. Section near spherical flaw shown in Fig. 7. HNO_3 etchin. × 150. Fig. 37. Traces left after dissolution of MnS inclusions in decarbonized flake. Sample 3872, party F. HNO_3 etching. × 50. Fig. 38. Grain fragmentation in sample 234PI from party F. Iodine etching. × 40. Fig. 39. Phosphorus segregations in 2379 from party G. HNO_3 etching. × 50.



FIGS. 40 AND 41

Fig. 40. Split test bars, etched for dendritic markings. Natural size. Fig. 41. Accepted and defective test bars, split and etched for dendritic markings. × 1.5.

by a higher ductility of the fibrous than of the non-fibrous material. The fibrous part would yield earlier and act as a notch to fracture the rest of the bar. Sample 2379 from party G differs from the rest in that it shows phosphorus segregation with a large grain formation in a cut parallel to the fibers (Fig. 39), and these segregations can easily explain the presence of a fibrous fracture. There was also a noticeable difference in the tests of 2164 2, 3 and 4 which were taken out of the forging a couple of inches apart and parallel to one another. All had the same microstructure. Examination of the fractures showed a few small "traces"[5] in No. 2 apparently from slag protruding at an angle with the fracture; in 3 and 4, however, there were more particles which were parallel to the fracture. A section was cut through the bars parallel to the direction of forging and etched with Stead's reagent, with the result that 4 showed a much stronger phosphorus segregation than 2.

Dendritic Structure

This brought up the question whether the fibers were caused primarily by phosphorus segregation of the dendrites or whether slag streaks must be present for the formation of fibers. Several samples of cup fractures, one from party C with fibers and slag traces and two others from party B with cup fractures and no traces or fibers, were then cut parallel to the direction of work and the microstructure developed as shown in Fig. 40 (bar from C in middle). Where no slag streaks are present, fibers do not show up on pulling the bar transversely. Etching for transverse dendrites in laminated and cut fractures in Ni steel, from party A (Fig. 41), shows no difference.

Another possible cause for flake may be segregated spots such as are exhibited by the variable-hued grains in Fig. 23. Hard spots are very often found in steel and are mostly phosphorus segregations, or they may be caused by incomplete solution of ferromanganese[6].

Summary

From the foregoing the author has endeavored to show that the predominant cause for flakes is slag inclusions. They may less often be caused by cracks formed by faulty mill practice, by blowholes or segregations. No distinct microstructure is found associated with flakes; therefore in general heat treatment is powerless to cure them.

In a subsequent communication the correct furnace practice to follow to reduce slag inclusions to a minimum will be discussed, which procedure has in practice largely reduced the rejections in plants which have adopted it.

Carnegie Institute of Technology,
Pittsburgh, Pa.

[5] As previously noted, "traces" are shiny smooth spots from which slag particles have fallen.

[6] Harden, METALLURGICAL & CHEMICAL ENGINEERING, 1917, p. 702.

Melting Points of Chemical Elements, and Other Standard Temperatures

THE following table of melting points of the chemical elements is issued by the Bureau of Standards in answer to numerous requests for this information:

The values of the melting points used by the Bureau as standard temperatures for the calibration of thermometers and pyrometers are indicated in capitals. The other values have been assigned after a careful survey of all the available data.

As nearly as may be, all values, in particular the standard points, have been reduced to a common scale, the thermodynamic scale. For high temperatures, and for use with optical pyrometers, this scale is satisfied very exactly by taking $c_2 = 14\,350$ in the formula for Wien's law connecting $I\lambda$ monochromatic luminous intensity of wave length λ, and T, absolute temperature: $I_\lambda = c_1\lambda^{-5}e'^{\frac{c_2}{\lambda T}}$. For all purposes, except the most accurate investigations, the thermodynamic scale is identical with any of the gas scales.

At high temperatures some of the values are quite uncertain; thus, while the melting point of platinum may be considered accurately known to 10 deg. C., that of tungsten is possibly uncertain by 50 deg. C. or more. Temperatures Centigrade are rounded off, and the exact Fahrenheit equivalents are usually given.

MELTING POINTS OF THE CHEMICAL ELEMENTS

Element	C	F	Element	C	F
Helium	<—271	<—456	Arsenic	850	1562
Hydrogen	—259	—434	Barium	850	1562
Neon	—253?	—423	Praseodymium	940	1724
Fluorine	—223	—369	Germanium	958	1756
Oxygen	—218	—360	SILVER	960.5	1760.9
Nitrogen	—210	—346	GOLD	1063.0	1945.5
Argon	—188	—306	COPPER	1083.0	1981.4
Krypton	—169	—272	Manganese	1230	2246
Xenon	—140	—220	Beryllium (Glucinum)	1280	2336
Chlorine	—101.5	—150.7	Samarium	1300–1400	2370–2550
MERCURY	— 38.87	— 37.97	Scandium	?	...
Bromine	— 7.3	+ 18.9	Silicon	1420	2588
Caesium	+26	79	NICKEL	1452	2646
Gallium	30	86	Cobalt	1480	2696
Rubidium	38	100	Yttrium	1490	2714
Phosphorus	44	111	IRON	1530	2786
Potassium	62.3	144.1	PALLADIUM	1549	2820
Sodium	97.5	207.5	Chromium	1615	2939
Iodine	113.5	236.3	Zirconium	1700?	3090
Sulphur S_I	112.8	235.0	Columbium (Niobium)	1700?	3090
Sulphur S_{II}	119.2	246.6	Thorium	≥1700?	>3090
Sulphur S_{III}	106.8	224.2		<Mo.	<Mo.
Indium	155	311	Vanadium	1720	3128
Lithium	186	367	PLATINUM	1755	3191
Selenium	217–220	423–428	Ytterbium	?	...
TIN	231.9	449.4	Titanium	1800	3272
Bismuth	271	520	Uranium	<1850	<3360
Thallium	302	576	Rhodium	1950	3542
CADMIUM	320.9	609.6	Boron	2200–2500?	4000–4500
LEAD	327.4	621.3	Iridium	2350?	4260
ZINC	419.4	786.9	Ruthenium	2450?	4440
Tellurium	452	846	Molybdenum	2550	4620
ANTIMONY	630.0	1166.0	Osmium	2700?	4890
Cerium	640	1184	Tantalum	2900	5250
Magnesium	651	1204	TUNGSTEN	3400	6152
ALUMINUM	658.7	1217.7	Carbon	>3600	>6500
Radium	700	1292			
Calcium	810	1490			
Lanthanum	810?	1490			
Strontium	>Ca<Ba?	...			
Neodymium	840?	1544			

OTHER STANDARD TEMPERATURES

Substance	Phenomenon	C	F	Variation with Pressure (Pressure in mm. of Hg)
OXYGEN	Boiling	—183.0	—297.4	$C° = -183.0 + 0.01258\,(p-760) - 0.0000079\,(p-760)^2$
CARBON DIOXIDE	Sublimation	— 78.5	—109.3	$C° = -78.5 + 0.01595\,(p-760) - 0.0000111\,(p-760)^2$
SODIUM SULPHATE $Na_2SO_4 + 10H_2O$	Transformation into anhydrous salt	32.384	90.291	
WATER	Boiling	100	212	$C° = 100 + 0.03670\,(p-760) - 0.00002046\,(p-760)^2$
NAPHTHALENE	Boiling	217.96	424.33	$C° = 217.96 + 0.058\,(p-760)$
BENZOPHENONE	Boiling	305.9	582.6	$C° = 305.9 + 0.063\,(p-760)$
SULPHUR	Boiling	444.6	832.3	$C° = 444.6 + 0.0908\,(p-760) - 0.000047\,(p-760)^2$
$3Ag2Cu$	Eutectic freezing	779	1434	
SODIUM CHLORIDE	Freezing	801	1474	

Solid Rubber Tires

History of Solid Rubber Tire Development, Sidewire and Wired-on Types—Bands—Hard Rubber Base, Methods of Applying and Quality of Stock—Calendered and Tubed Treads, Manufacturing Processes and Comparison of Tires—Testing of Solid Tires, Specifications

By ANDREW H. KING

THE USE of solid rubber tires depends on two main characteristics. First and foremost, they tend to equalize road surfaces, protecting both vehicle and rider from shock. In this a solid tire is very inferior to the pneumatic. Rubber cannot be compressed. It can only be deformed and to an extent dependent on the degree of loading of the stock. Solid tires are heavily loaded. By this I mean that more than 30 per cent of the volume of the tire is something other than rubber. In present practice zinc oxide, or lampblack, or both are chiefly used. The normal elasticity of rubber is greatly reduced. On the other hand a pneumatic tire depends on rubber and fabric only to provide the container for the true carrier, which is air under pressure. In common with other gases it is approximately perfectly elastic. It can be compressed at will. For this reason it provides the ideal cushion. However, solid tires are unquestionably greatly superior to a steel band, and their introduction during the early '80s for carriages was indeed a great step.

The second function did not develop until after motor-driven vehicles were introduced, when they were required to provide traction. This brought about a widening of the tire and a decrease in its diameter. From this standpoint the solid tire is satisfactory as long as it is kept on good roads. It is useless in mud, or on wet, slippery asphalt paving.

Solid vs. Pneumatic Tires

As is well known, the solid rubber tire was first introduced for carriages. Then followed the advent of the automobile with its greater speed, when the pneumatic tire largely replaced it for pleasure vehicles. But the development of the motor truck has given it a new lease on life. Here pneumatics in large size were until the past year or so unavailable. Even yet they are more expensive, liable to puncture, and not wholly satisfactory. The solid tire is dependable, it lasts a long time, and can carry a high overload for a short distance without danger. One prominent exponent of pneumatic truck tires is confident that history will repeat itself and that the solid truck tire will eventually give way to the pneumatic. Perhaps he is right, but for some years to come the manufacture of solid tires will continue.

There is no great certainty as to when solid rubber tires were first introduced, but we do know that their use was nowhere general until they were applied to the extensive line of hansom cabs operated in London in the early '80s by the Shewsbury & Talbot Noiseless Tire & Cab Co. Their tire had been invented by Carmont, whose patents were granted in 1881 and 1883. By the original definition, it was a rubber tire held in a rolled steel channel in a state of compression between converging flanges.

Fastening to the Wheel a Problem

It is well to digress at this point and to note that the great difficulty in tire design was not to provide a stock which would stand up well under the conditions of service, but the problem was how to fasten such a tire to the wheel. For Carmont's purposes compression in a steel channel was sufficient. But by so doing he decreased the readiness with which his tire was deformed. It was hard, and except for being noiseless was little better than the steel band.

The logical advance from this stage was, of course, to the "wired-on" type. Grant[1] held his tire in place by means of longitudinal wires, two at first and more for larger sizes. His channels were not as deep as those of Carmont. More rubber was exposed for wear, and as there was no compression the tire had greater resiliency.

The Burgess tire was similar to the Carmont except that he introduced longitudinal wires which had been wrapped with small special wires for the protection of the rubber. The Victor tire was similar to Grant's, but the wires were encased in leather.

Many Types Designed

Easier of application, but similar in principle, was the "sidewire type," known also as the Firestone and as the Swinehart & Byrider[2], who were the patentees. It was held in place by two endless retaining wires which were sprung over the edges of the channel and engaged the ends of embedded cross wires or bars. In this way the tire was held securely in place.

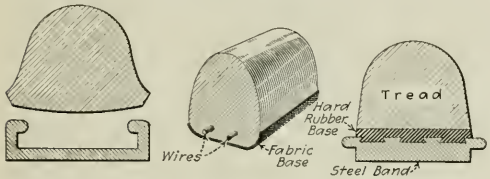
The various "wired-on" types are reasonably satisfactory in sizes up to 2¾ in. in width; i.e., for buggies, carriages, victorias, etc., where the tire is not required to transmit traction. In larger sizes and where "traction" must be furnished, the strain on the stock next the retaining wires causes tearing, which ultimately throws the tire. This difficulty led to the development of many very ingenious designs. The splice which proved such a difficulty in the "wired-on" type was eliminated. The new tire was endless, i.e., spliced, and fastened in the uncured condition to a special band which was so designed as to be easily mounted on the wheel, usually by removing a flange which when bolted in place held the tire securely.

No mechanical method of fastening the tire to the band proved satisfactory. Wires, steel rods, bands, etc., no matter how complicated, all cut or tore the tire when

[1] U. S. Pat. 554,675, 1896.
[2] U. S. Pat. 686,556, 1901.

placed under strain. The solution of the problem was very simple, and was developed in Germany by the Metzler Co. They dispensed with all wires, hooks, etc., and interposed between the steel band and the tire a hard rubber base which securely united them. To strengthen the union to the band they introduced an ingenious system of dovetailing. In this way no local strain was placed on the tire, the load being taken uniformly by the whole base of the tread. This type of tire has now come to be accepted as the standard form.

There are two ways of fastening such a tire to the wheel. For the smaller sizes (3 to 5 in. in width) bolts and flanges are satisfactory. For larger widths the traction is too great and a larger number of bolts are necessary for secure fastening. To combat this



FIGS. 1, 2 AND 3. ON LEFT, SECTION OF CARMONT'S TIRE. IN CENTER, GRANT'S TIRE—STANDARD AMERICAN CARRIAGE TIRE. ON RIGHT, METZLER'S TIRE

trouble the "pressed-on" type was developed. The band is forced on the wheel by hydraulic pressure. It is placed under considerable tension, which effectually prevents any creeping of the tire on the wheel. At the present writing very few bolted-on tires are made. The pressed-on tire with a hard rubber base is apparently the last word in solid tire design.

Solid tires may be classified in three broad divisions, namely, carriage, truck and cushion. The essential details of manufacture are outlined below.

Carriage Tires

The chief demand for rubber tired carriages is found today in certain parts of the South, Canada and South America, regions where the "flivver" is as yet unknown or impossible because of bad roads.

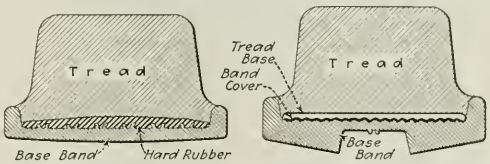
Carriage tires are shipped to the various wagon shops in reels of variable lengths and in widths running from ½ to 2¾ in., depending considerably on the purpose for which the tire is intended. Under this head is included the cheap grade which is made in small sizes for invalid chairs, etc.

Stock: The compound employed will vary with the severity of the service. The chief considerations are price, specific gravity, body, strength, easy working, a certain degree of hardness, and a reasonable "give." To keep the cost down very little rubber is used. Shoddies are quite satisfactory. The "body," or, expressed differently, the degree of loading, is very important. To tube nicely the stock must be firm but not too soft and never very sticky. The proper balance of these qualities is unfortunately only learned by experience, and is almost impossible to describe. The curing agents must be carefully chosen. The accelerator must not be high powered or it will be liable to cure the stock in the tube machine. A common fault with many carriage tires is slight blowing which is indicative of an unbalanced formula or an insufficient quantity of stock in the mold, thus preventing proper pressure on the tire during curing.

Milling and Warming Up: Many carriage tire formulas give a batch which is difficult to handle on the mills. There is little if any rubber to hold it together and frequently asphaltic or other sticky material will be present in quantity. For the poorer grades a scraper attachment is absolutely necessary, as the stock cannot be batched off by the mill man. The scraper is a knife 6 to 8 in. wide fastened to the end of a lever, the fulcrum of which can be slid back and forth in a direction parallel to the length of the rolls. When the batch leaves the mills it is in ideal state for tubing. It is soft, plastic, and will take almost any shape imposed. But no tube machine can be operated efficiently without a supply of stock on hand. Therefore it is necessary to install a warming up mill in close proximity to the tube machine.

The Tube Machine

Tubing: The tube machine is designed and operated on the same principle as the old-fashioned sausage grinder and stuffer. Pieces of warmed stock, cut to convenient size, are fed by hand. A worm which operates in a casing carries it forward, packing the stock tightly together all the while. At the end of the worm it enters a sleeve which reduces it in diameter, and then passes through a die. Except for being power driven and stronger and heavier it is exactly like a sausage machine. Since shoddies frequently contain pieces of metal, a wire screen is sometimes placed in the sleeve to intercept them. The internal wire holes of the "wired on" tires are made by attaching to either the die or the carrier two metal forks which project through the opening. As the stock passes beyond the die the compression is removed and the holes remain intact. Considerable experience is required in adjusting the temperature of the die, which is regulated by a skilled operator with an ordinary bunsen burner. As all stocks do not tube well at the same temperature,



FIGS. 4 AND 5. SECTIONS OF STANDARD SOLID TIRES. ON LEFT, "PRESSED-ON" TYPE, ONE HARD RUBBER. ON RIGHT, "BOLTED-ON" TYPE, TWO HARD RUBBERS

no little experimenting is required before the best conditions are arrived at. The casing is jacketed and is provided with means for heating and cooling similar to the ordinary mill. As the tire leaves the tube machine it passes first through powdered soapstone and then through revolving brushes which remove the excess. At this point it is picked up by a conveyor belt traveling at slow speed. When the desired length is attained, which depends solely on the length of the heaters, the operator cuts it off and throws it into a tray, after which soapstone is blown through the wire holes.

Cheap tires, such as the poorer grades of baby carriage tires, are not handled quite in this manner. As

the tire comes from the tube machine it is coiled up on a circular rotating board. When the board is full the tires are dusted with soapstone. Such tires are not infrequently given an "open steam" cure. The board is covered with a layer of soapstone an inch or more in depth and put directly in the heater without any wrapping whatever. The procedure is not very satisfactory, but is sufficient for the quality of goods produced.

Wiring: Wires of the proper size are inserted in the holes in rather a clever manner. The nozzle of a compressed air line is pressed tightly against the holes at the opposite end from which the wires are to be inserted. The holes are slightly distended when the wires are started through, thus allowing them to slide in on a cushion of air.

Curing: Only a small portion of the annual carriage tire production is cured under hydraulic pressure. Us-

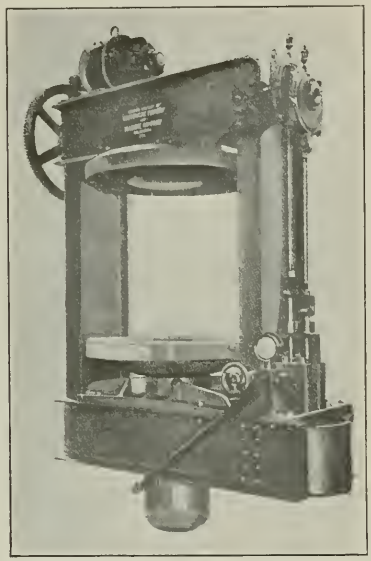


FIG. 6. 200-TON PRESS FOR FORCING SOLID TIRES ON OR OFF WHEELS

ually full dependence is placed on a series of bolts which are tightened down by the heater men. The heaters are quite long, varying from 20 to 50 ft. in length, and consist essentially of two steam heated platens. The steel molds are detachable, so that the same heater may be used for curing tires of various widths. At each end of the platen are spaces a foot or more in length, which are spoken of as "dead" or "cold" ends. As will be seen later, they are very convenient in splicing the successive lengths into a long reel.

The Usual Curing Procedure

The usual curing procedure is as follows: The wired lengths are placed in the mold face down. The bases are scrubbed with gasoline to remove the soapstone, then given a coat of cement, and the tape, frictioned on one side, is applied. The fabric backing gives the tire a longer life. This length is spliced to the preceding one as follows: It projects, let us say, one foot into the left "dead end," which brings it a foot from the right "dead end," on which side the reel is located. The uncured end of the previous length is hauled down, the ends of both tires cemented and joined together. The tape is carried six inches or a foot beyond the splice. This leaves a section of the cured portion in the right "dead end." Some presses are designed with only the left "dead end," but they are not quite as satisfactory as those described above. The top platen, which is raised and lowered by a chain block, usually electrically driven, is set in place and bolted down.

When the period of vulcanization is completed the first step is to remove the wires, which is sometimes very difficult. The operator grasps the end of the wire with a special set of forceps which are designed so as to give him a firm hold and a long leverage. He twists and turns the wire until it is loose in its cavity. By applying compressed air at the end of the reel as before, the wire is drawn out without further trouble. Wires which have been in constant use for some time require an occasional bath in caustic soda to clean them.

The tire is trimmed by passing between two revolving knives, which remove the "rind." The lengths are measured, weighed, and wound on reels, when they are ready for shipment.

Applying Tire to Wheel

Application: The method of applying such a tire to the wheel is interesting. Special apparatus, of which there are numerous designs, is required. Three things must be done simultaneously. The wheel must be firmly held so as not to rotate, the wires must be placed under tension, and the tire itself must be compressed, i.e., slid back from the splice a distance of at least eight inches. Then the wires are brazed together. The ends of the tire are cleaned with solvent, given a coat of cement, and acid cured by brushing a little sulphur chloride solution over the cemented ends and bringing them quickly together.

Carriage tires must stand up on all kinds of rocky, muddy and sandy roads. They must have great resistance to abrasion and must age well. The old carriage tire man put a suitable product on the market long before the era of testing machines. He depended upon a few simple tests which are worthy of brief mention.

Slice Tests: By snapping a thin slice cut perpendicular to base of the tire but not quite to the wire holes one is able to judge very closely as to the spring, elasticity and cure of the tire. The force required to pull this piece off gives a measure of the tensile strength of the stock.

Tread tearing: The face of the tire is cut back at a small angle so as to give a hand hold. Pressure is then applied to separate tread from base. The force required furnishes an index as to the wearing value of the compound.

Twisting: One should be able to twist a good tire a number of times, and find on releasing that it regains almost completely its original shape. Many cheap tires are so loaded with asphaltic material that they appear dead and lifeless. They do not even approach their original shape.

Bending: The surface of the tire should show no

checking or cracking when bent through 180 deg. and the surface scratched with the back of a knife or the finger nail.

Hardness: If the point of a pencil is pressed straight down into the tire the pressure required is an index of the hardness, and the rate of recovery shows the nature of the stock.

The tensile strength of carriage tire stocks usually varies from 700 to 1200 lb. per sq.in. The stretch runs from 200 to 350 per cent. The set (Bureau of Standards method) is from 15 to 35 per cent.

The life of a good tire is very long. This is partly due to the intermittent service it receives, and partly to the light loads carried.

Truck Tires

As indicated above, practically all truck tires are built on steel bands which are either bolted on or pressed on to the wheel. Pressed-on tires make up a very high percentage of the total output. Except for slight variation in the design of the band, there is no difference between the two types, and they will be considered together without further mention. The essential parts of the tire are: The band, hard rubber base, and the tread. They will be considered in order.

Bands: They are of mild steel corrugated and rolled to the desired width and design at the mill, and are usually delivered to the manufacturer in long lengths. He then bends them to the desired diameter and welds the splice, usually with electric welders. Before the bands are ready for covering they must be sand-blasted to remove any rust. Blasting also slightly roughens the surface, which causes the band cover to stick much better.

Hard Rubber Base: This is beyond question the critical part of the tire, and that on which its success is largely dependent. Several manufacturers have recently learned to their sorrow that poor hard rubber ruins a tire. If it does not cure up properly, or if it does not stick well to both band and tread, they will separate. This is the end of the tire regardless of how good the tread may be. Union to either band or tread is fairly easy, but to both is quite difficult. The presence of corrugations and uneven grooves in the band allow a softer hard rubber to be used as they increase the union. This is perhaps the poorest solution to the problem, but many good tires are made after this fashion.

One or two makers of tires do not depend on just one hard rubber. They use two. The band cover, i.e., the one in contact with the band, is completely cured up and sticks to it very well. On top of this is the tread base, which is a semi-hard rubber. It sticks well to both band cover and tread.

Applying the Band Cover

This is perhaps the best scheme, though it must be more expensive. In either case the first step is to apply the band cover. The sand-blasted band is placed on a revolving spider or chuck. A number of spiders are mounted in a long row. Each one is belt-driven from a shaft overhead, but is fitted with a clutch so that it may be started and stopped at will. The band surface is cleaned first with wire brushes to remove any sand or scale and then with gasoline or benzol to remove any grease. The solvent used must be free from grease and sufficiently volatile so that none remains a few minutes after washing. The green stock is milled, calendered, and cut into proper width and length in the usual manner. The end of strip is pressed down on the band with care that it is in proper alignment. The band is started slowly and the stock pressed down with a wide flat roller. Then the speed is increased and a narrow stitcher is used. This presses the stock tightly into the grooves. Where any individual design is to be given to the hard rubber a special roller is used to finish it. Next the surface is washed well with solvent

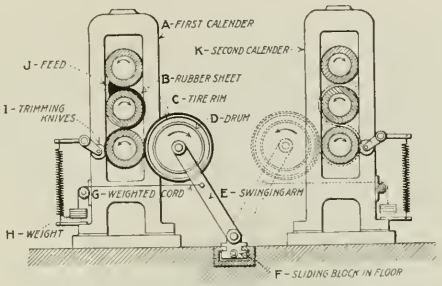


FIG. 7. GRAY'S APPARATUS FOR CALENDERING SOLID TIRES

and allowed to dry. If there is only one hard rubber to be used, the band is now ready for the tread. Tread base procedure will be described later.

Tread: Formerly most treads were made up of two or even three different types of stock. But this has now been practically abandoned and only one kind is used for the tread. There are two general methods by which the tread is prepared, i.e., calendering and tubing. The former will be considered first.

Calendered Tread

The steps here are as follows:

Filling the Band: The covered band (i.e., covered with hard rubber) must be filled with tread stock to a little past the edges of the channel. Filling is usually done by hand, using strips of calendered stock.

Treading: The filled band is placed on a special apparatus for holding it against the lower roll of the calender. Two designs are indicated in the accompanying sketches. Fig. 7 is representative of old practice when more than one tread stock was used. The tire is built to a certain thickness on one calender and is then thrown over to the other calender, where the second tread is applied. This design is weak in that the pressure under which the stock winds up is not very great. Present practice is better. The tire is mounted on a chuck which is carried by the piston rod of a compressed air cylinder. With this apparatus the tire is built up under pressure. The plies stick together better and the tire lasts longer in service. When one tire is completed the apparatus is rotated. This brings another band into position.

Trimming: When the tire leaves the calender it is rectangular. It must be trimmed to the section of a trapezoid and if the size is 10 in. or over it must be grooved according to best practice. This is accomplished by placing it on a revolving chuck, rotating it at high speed and advancing a knife in a manner similar to the

handling of the cutting tool on a lathe. The grooving is done with a special spoon shaped knife.

Several manufacturers use the calender process for tires 10 in. or more in width, and many others make all sizes from 7 in. up in this way. For sizes in excess of 7 in. a very large tube machine is required, and the difficulties incident to handling so much stock efficiently are not small. There is said to be but little difference in cost between tubed and calendered tires, though the writer believes the latter has a shade the edge on the former.

Tubed Tread

The stock is prepared in the usual manner. It is customary to use two or even three warming up mills to keep the tube machine well supplied. It is similar in design to the one described under carriage tires, but is many times larger and stronger. The die gives the tire its approximate shape. There are two general procedures for handling such tires, known as the hot and cold methods respectively.

Hot Method: The tire as it comes from the machine is applied directly to the covered band, which has been placed on a revolving chuck close by. The proper length is cut off and the splice made with the hot stock. It

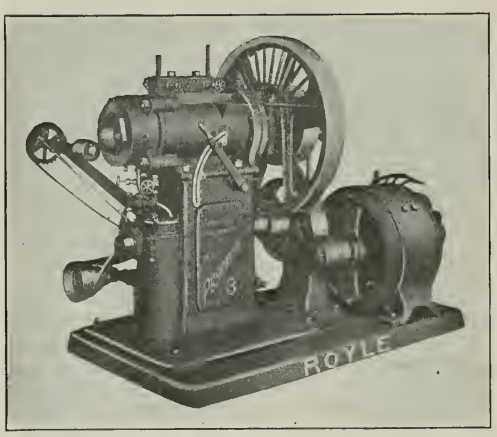


FIG. 8. TUBE MACHINE, SIZE SUITABLE FOR CARRIAGE TIRES

then goes to the power stitcher, where the thread is forced in close union with the hard rubber base. The power stitchers are two fair sized rollers, power operated. The lower roller supports the band and the top one is lowered by means of a screw so as to bring pressure to bear on the thread. After trimming off any stock which has been forced out the tire is ready for curing.

The hot method is quick, cheap and very efficient; but does not give entirely satisfactory unions, due perhaps to a semi-curing of the hard rubber.

Cold Method: Formerly all tires were tubes in single stick lengths just the same as carriage tires. But now several factories run a double stick and saw the two halves apart. This practice is, of course, impossible when tires are handled by the hot method, but for the one being described it is very appropriate. It is cheap, efficient, and produces a better tire.

Process by Cold Method

The double stick is picked up by a slow moving conveyor belt as it leaves the tube machine. When the proper length is reached it is cut off, rolled over on a board, weighed, and allowed to cool. When the stock shows a tendency to swell unevenly on cooling, it is often necessary to drop the stick into steel forms, where it remains until quite cold.

Sawing: The stick is cut into two treads by a rapidly moving band saw, the blade of which has very small teeth or none at all. A special feeding device is employed to hold the parts firmly and at the same time keep them separated. The design ordinarily used is a combination of a conveyor belt with a number of grooved rollers.

Tread Base: Where only one hard rubber is used, the tread goes direct to the building room, where it is spliced and placed on the band. Because of the value of the two-hard-rubber tire, we will take up now the tread base. As above mentioned, it is a semi-hard rubber designed to unite the tread and band cover. Milling and calendering of the stock is according to usual practice. It arrives in the applying room wound up in narrow reels.

The sawed treads are placed on a rack face down. The bases are washed well with either gasoline or benzol and allowed to dry in an atmosphere free from dust. When dry they are loaded on a conveyor, which delivers them to the rolling machine. This is a simple contrivance which increases the efficiency of the application. The reel of tread base is hung overhead and unwrapped as needed. When the conveyor delivers a fresh tread, the machine is stopped and the tread base firmly attached for about an inch, after which the work proceeds. The tread and base pass under a wide roller, which presses them firmly together, thus producing a very good union. As the tread comes out on the other side of the roller the edges are trimmed, usually with a V-shaped knife whose inner edges are sharpened. The stick is cut to proper length and receives its final weighing. The upper surface of the tread base requires washing to remove dust. Sometimes a coat of cement is necessary. When the stocks are dry and do not unite easily, it is usual practice to cement both tread and hard rubber regardless as to whether one or two stocks are in use.

Splicing Methods

Splice: There are two methods of cutting the stick for splicing. In some factories the cut is made square. This is known as a butt splice. The other and most usual form is the diagonal splice. The stock is cut at a 45 deg. angle so as to give longer joining surface.

The cut ends are washed with solvent, dried, and placed in the jammer. It consists of two clamps having wide knurled faces. One clamp is fixed, but the other is movable. Considerable force is applied by means of a fairly long lever, thus effectually pressing the ends together. The stock is held under pressure only a minute or so. The method is very good. The joint is stronger than the green stock anywhere else in the tire.

Application to Band: The tread is now a ring. The

band is placed on a circular table, which may be rotated. The ring is stretched and fitted over the band by means of rubber mallets and a set of three or more irons which are similar in shape to carpenters' wood chisels. Then the edges are stitched under the sides of the band with narrow steel stitchers. From the applying table the tire goes to the power stitcher, where the tread and hard rubber are pressed tightly together.

Curing

In the foregoing we have covered the principal variations in the preparation of "pressed-on" or "bolted-on" truck tires, bringing them all to the state when they are ready for curing.

All truck tires are cured in autoclave presses in heavy sectional cast iron molds. The heaters are set so that their upper edge is about 2 ft. above the floor of the pit, which is the name applied to the curing room. They are massively built. From twenty to thirty tires can be cured at one heat. This type of heater combines the advantages of press and open steam cure. The molds and tires are accurately heated throughout and the desired hydraulic pressure is applied at the same time. The lid of the heater is secured by bolts or by a system of slots. The latter form is now most in use. The lid drops in place and is locked by turning it a distance of about six inches. It serves as a backstop for the hydraulic ram, which is placed in the bottom of the heater. Pressure is transmitted through the molds to the lid.

Because of the extreme thickness of the stock to be vulcanized, a rising cure is absolutely necessary. The first stage is of short duration and low temperature. The second and third are progressively longer and at higher temperatures. Three raises are usually sufficient, but some of the very large truck tires require four. When the period is ended the steam and hydraulic are shut off, the heater drained, and the lid removed. Then it is filled with cold water to cool the molds sufficiently for handling. When cool, water pressure is applied to the ram and the load gradually raised. The molds are opened with bars and the parts carried off by chain blocks which run on an overhead trolley.

The tires are removed, trimmed and inspected. They are then ready for sale.

Comparison of Tubed and Calendered Tires

In a calendered tire the plies are wound up spirally. The grain is therefore circumferential. Maximum strength is in this direction. The tire is weakest across the grain. Tearing takes place with the grain, i.e., parallel to the circumference. The bond between the plies is comparatively weak. When a calendered tire fails in service it is usually because of ply separation or tearing with the grain.

When a tire is tubed in a single stick, the grain runs in concentric cones along an imaginary line through its center parallel to its length. Such tires develop in service peculiar looking tears and cuts, which of course follow the lines of the grain. When the tire is tubed in the double stick, the grain is in the same direction, but the ends are tied down to the hard rubber base, thus presenting a fairly uniform resistance to cutting, etc. However, when the stock is not of quite the right texture due to stiff crude rubbers, or for any reason such as when it does not receive proper compression in the tube machine, there is a distinct line of weakness along the grain and the tires develop herringbone breaks after a short time in service.

It is still an open question as to which is the better, calendered or tubed tires. The main objection to calendered tires is ply separation, and to tubed tires herringbone breaks.

Testing of Solid Tires

Notwithstanding the action of the Government in discontinuing the Barbecue test, the writer feels that this is the best way to obtain an accurate knowledge of the state of things within the tire.

Barbecue Test: The tire is placed in a vise and securely fastened. By means of a knife a long, slanting cut is made in such a way as to separate about 18 in. of tread. Around this a rope is looped, which is in turn

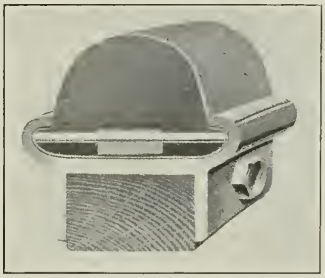


FIG. 9. SOFT-BASE TRUCK TIRE

fastened to a steel cable connected through a dynamometer to a chain block. A little tension is applied and the tread cut through, down to the hard rubber. Load is gradually increased and the trend union determined by the pounds pull required to separate it from the hard rubber. Former Government specifications required at least 100 lb. per inch of width. Thus a 6-in. tire was required to show a tread union of 600 lb. or more. As a matter of fact, the better grades of truck tires run much above this. Some go as high as 200 or even 300 lb. per inch of width.

The union of the hard rubber to the band is examined with a hammer and chisel. It should be so good that one can separate a piece of hard rubber within itself easier than it can be removed from the band. Where two hard rubbers are used, they should adhere so tightly that they cannot be separated. A section of tread is cut off squarely and placed in a slicing machine. It is similar in design to those used in butcher shops for slicing bacon, etc., but is much heavier and has a power drive. Both longitudinal and transverse sections are cut. Transverse slices are tested by the compounder for cure and feel. Regular tests for tensile strength, etc., are made on the others.

In view of Government specifications covering solid rubber tires the tendency has been for all makers to bring their product somewhere near the quality required. Therefore the following abstract of specification No. 1074-A may be taken as descriptive of American truck tire practice to-day.

1. *Rubber:* The compound shall contain not less than 65 per cent by volume best quality wild or plantation rubber. Shoddy or mineral rubber when used is to be in addition to this 65 per cent. Refined or ground vulcanized rubber is barred.

2. *Sulphur:* Not more than 8 per cent on the weight of crude rubber employed. This figure is plenty high.

3. *Saponifiable Matter:* Saponifiable oils or anything made from them are barred. This eliminates rubber substitutes.

4. *Tensile Strength:* They divide tires into two classes. (*a*) Those where the specific gravity is 1.40 or over (high zinc oxide) shall have a minimum tensile of 1800 lb. per sq.in. (*b*) Those having a specific gravity of under 1.40 (high lampblack) must have a minimum tensile of 2000 lb. per sq.in.

5. *Stretch:* Standard is placed at 350 per cent.

6. *Set:* Not over 40 per cent two minutes after rupture is maximum.

7. *Aging:* After heating two hours in an oven at 228 deg. F. the depreciation when tested 24 hr. later is to be not more than 35 per cent in elongation.

8. *Adhesion:* The tire is placed horizontally on the platen of a tire applying press, supporting it on a steel band having the same diameter as the base of the tire to be tested. On the upper side a band $\frac{3}{4}$ in. thick with an inside diameter $1\frac{1}{2}$ in. larger than the outside diameter of flange of base band is applied. The corners of this band are rounded with $\frac{1}{4}$ in. radius. The various sizes of tires are to be submitted respectively to pressures in accordance with the following table. For the tire to pass successfully the hard rubber must not break loose from the base.

9. *Life:* A minimum life of 7000 miles per tire must be assured.

Size of Tire	In. Diam. of Press Ring	Lb. per Lineal Inch	Pressure in Tons on Tire, Max.	Size of Tire	In. Diam. of Press Ring	Lb. per Lineal Inch	Pressure in Tons on Tire, Max.
32x3	29	175	8	32x3½	29	220	10
34x3	31	175	9	34x3½	31	220	11
36x3	33	175	9	36x3½	33	220	11
32x4	29	325	14	32x5	29	400	18
34x4	31	325	16	34x5	31	400	19
36x4	33	325	17	36x5	33	400	21
38x4	35	325	18	38x5	35	400	23
40x4	37	325	19	40x5	37	400	23
42x4	39	325	20	42x5	39	400	24
32x6	29	475	21	36x7	33	550	28
34x6	31	475	23	38x7	35	550	30
36x6	33	475	24	40x7	37	550	31
38x6	35	475	26	42x7	39	550	33
40x6	37	475	27	36x8	33	550	29
42x6	39	475	29	40x8	37	550	33
1110x100 mm.	47	325	24	1000x125 mm.	43	400	27

The above gives an idea of the service which may reasonably be expected of a solid tire. If it is well built and of good material properly compounded, it will give

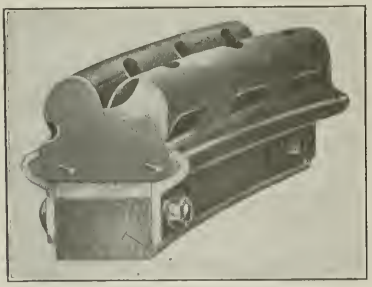


FIG. 10. CUSHION TIRE FOR ELECTRICS

good service, with the final provision that it receive fair treatment. It must not be overloaded, driven at speed higher than allowed, or run for long periods of time without being given a chance to cool off. When heavy loads are to be carried it is preferable in point of service to substitute duals for a single large tire. Thus where a 14-in. size is necessary two 7-in. tires will be found more satisfactory.

The compounding of solid tires is not easy. There are so many factors that must be handled to a nicety that it is hard to get the proper balance between them. The chief difficulties may be stated as follows:

(*a*) *Union:* The hard rubber must make good union with both tread and band.

(*b*) *Body and Hardness of Tread:* The stock used here must be heavily compounded so as to stand up well under the load. If it is too soft it will cut and large chunks will be torn out.

(*c*) *Easy Working:* The stock must be of a nature which will allow it to tube readily.

Cushion Tires

The cushion tire is a hybrid. It is both a solid and a pneumatic—and neither. It is merely a solid tire with a hole in it. The hole may be either inside or outside. There have been advanced more than a thousand designs based on this principle, but none of them ever become really popular. The reason is simple. If the tire is to function as a pneumatic, the walls of the air space are too heavy to stand the flexing without considerable heating up and subsequent decomposition.

The proposition is in some ways parallel to the tire filler (pneumatic). This phœnix is revived year after year, and sad to state the unsophisticated always fall for it. They forget that rubber is the most incompressible substance known. It can be easily deformed but never compressed. In designing a tire to carry a load one must first decide whether he will secure the desired cushioning solely by rubber itself or if air is more suitable. If after careful consideration of the conditions he decides on the first solution he will make a solid tire. If air is to be depended upon he will design the walls of his container in such a way that they will stand flexing.

The trouble with a cushion tire is that it will not stand any large amount of bending without suffering serious injury. In practically every instance where a cushion tire appears to give satisfaction it will be found that it has been very lightly loaded and the degree of flexing has not been high. One can safely say that there is no field for the cushion tire. Practically every application can be as well or better served by either a pneumatic or a solid. This does not mean that it may be substituted by both a pneumatic and a solid, but that one of the two will prove more satisfactory.

This statement must be qualified, however, since there is one very good place for the cushion tire with outside air spaces, and that is on small electrics. These cars are light, travel at slow speed over good streets, and are usually driven by women. Their advantage is twofold: first, the uneven surface gives it non-skid properties, and, second, there are no punctures. This fact means much to an elderly lady. To her the tire is reliable, for, like the famous flivver, "it gets you there and gets you back." She drives slowly, and the jolts are greatly decreased.

The manufacture of such tires is simple. The tube machine runs them out in sticks of the proper length and approximately the proper shape. The tires are built by hand. The fabric base is put on, and the tire spliced

in the usual way with the jammer. The knobs, depressions and special designs are put on in the molds during curing.

Stocks used for cushion tires are necessarily of a higher quality than for solids. They must have a higher tensile strength and higher stretch. The best of them will show a tensile strength of close to 3000 lb. per sq.in. and a stretch of 400 to 500 per cent.

Conclusion

The above is in general the history of solid tire development. During the war motor trucks were a deciding factor. They proved to be the red corpuscles not only of the battlefield but of industry. Every territory formerly dominated by the railroads has been seriously invaded. Surely the lessons learned in war will not be forgotten in peace. The next ten years will see the greatest truck expansion the world has ever known. With it will come extensive road building. The solid truck tire will dominate the field for a long time at least. Sales on pneumatic truck tires may be developed sufficiently to displace solids almost entirely, but the writer feels that an entirely new scheme of design will have to be worked out. Merely increasing the dimensions of the automobile tire will not prove successful.

The writer has attempted to set before the reader some of the salient features of solid tire design and manufacture, without going too much into detail. While the conclusions advanced are the result of his own observations and experience, he realizes very well that all solid tire men will not agree with him, and therefore offers them simply as his own opinions, which he believes in the main to be correct.

Our country undoubtedly faces a complete revision in transportation. Good roads will be constructed to every corner of the land. The bulk of our commerce will in the future be carried on trucks. Whether they will be equipped with solid or pneumatic tires is yet to be seen. It appears now that express trucks will ride pneumatics but that regular freight service will depend on solids. Good roads and plenty of gasoline or an efficient substitute will be found among the deciding factors.

Cleaning Furnace Gases Without the Use of Water

By J. C. Barrett
Superintendent of Blast Furnaces, Carnegie Steel Co., Youngstown District

Realizing the inefficiency of the various methods of cleaning and burning blast-furnace gases, F. E. Kling, chief mechanical engineer, and Luther B. Weidlein, experimental engineer of the Ohio works, Carnegie Steel Co., Youngstown, Ohio, five years ago started experiments to overcome the difficulties. In the course of their experiments, they developed a very efficient gas burner for boilers, which is truly an aspirating burner and fulfills the rigid specifications required for burning blast-furnace gas efficiently. After completing this phase of the problem, steps were taken to make a comparison of results obtained from burning gas which had been cleaned or partly cleaned by various means, and dirty gas taken directly from the dust catcher.

The first experiment was carried out with gas that had passed through an impinging type of wet washer. This type of washer was found to be very inefficient, as it reduced the temperature about 50 per cent, was not more than 50 per cent efficient in removing the dust, and the gas picked up about 15 per cent additional moisture. The item of reduced temperature alone was sufficient to condemn this method, disregarding the high dust content of the gas. Aside from the loss of the sensible heat due to reduced temperature and increased moisture content of the gas, the quantity of dust which the gas carried through the washer was just as detrimental to obtaining boiler and hot-blast-stove efficiency is if the gas had not been cleaned at all.

The next experiment was made with gas that had passed through the cleaning plant for gas engines, which includes a spray tower, baffle tower, and Theisen washer. Even if the gas were desirable for boilers or hot-blast stoves, this method of cleaning would be prohibitive from the standpoint of cost. A disadvantage of this method, disregarding the cost, is the fact that the sensible heat of the gas is reduced to such a point that the usual size combustion chamber is not long enough to obtain complete combustion. The gases, therefore, enter the boiler proper partly unburnt, coming in contact with the heating surface of the boiler, which is the temperature of the steam, causing the gases to give up the heat of combustion, thereby reducing the temperature of the unburnt gases below the ignition temperature, with the consequent incomplete combustion of the gases, resulting in a loss that might otherwise be prevented.

The moisture content of the gas was reduced to about 30 per cent of the original with this method of washing. To accomplish this, however, it was necessary to reduce the temperature of the gas to the temperature of the water used for cleaning. If the temperature and the moisture content of the gas entering the boiler were the same as in the waste gases leaving the boiler, it would not be possible to sustain the loss of a single B.t.u. With any normal operating condition of the blast furnace, there is a decided advantage in favor of retaining the temperature of the gas as coming from the furnace, even in view of the fact that the gas contains the additional amount of moisture. An experiment was then made with hot gas taken directly from the dust catcher, and much better results and efficiencies were obtained than with either of the former experiments, although large quantities of dust had to be contended with, and the dust had to be blown off the boiler tubes frequently.

In view of the results obtained from the above experiments, and the advantages so prominent in favor of hot gas, various means were employed to develop a cleaning method in which the dust could be removed from the gas without reducing the temperature. After careful study and experiment, a very novel means of removing the dust from the gas was developed, and an experimental cleaner was built, designed to handle 6000 cu.ft. gas per minute at 62 deg. F. This plant was in operation, off and on, for about six months, being taken off and changed as various improvements were developed. Results were obtained that were truly remarkable in view of the difficult problem of removing the very fine or impalpable powder from the gases—results that equal and surpass cleaning efficiencies of the best types of wet washers.

The gas passing through this experimental cleaner

was consumed under a 400-hp. Stirling boiler, and after a month's operation, without blowing the tubes, there was less than 50 deg. F. increase in temperature of waste gases on account of the dust accumulation. What little dust came through the cleaner was of such nature that a large portion of it was carried through the boiler and out with the waste gases. However, the portion deposited on the tubes was easily removed by blowing it with a hand steam lance. The dust carried by gas which has been wet-washed bakes onto the tubes and is hard to remove. During a slip of the furnace, the dry cleaned gas would burn as usual, while the flame would extinguish in an adjoining boiler, using wet washed gas, due to excessive dust. The boiler was completely equipped with recording instruments, and it was shown that it would not be necessary to blow the tube oftener than once in two to three weeks to maintain almost uniform boiler efficiency.

This experimental cleaner was inspected by various individuals and committees, and was pronounced a remarkable development, and one which would revolutionize cleaning methods for blast-furnace gases. Due to the very satisfactory results obtained from the above experiment, the United States Steel Corporation authorized the installation of a cleaner large enough to clean all of the gas from one blast furnace. This cleaner was installed at No. 1 blast furnace of the Ohio works, Carnegie Steel Co., Youngstown, Ohio, and was built and ready for operation without interfering with the operation of the blast furnace, the latter being banked only long enough to make a connection to the existing dust catcher. This furnace has a capacity of 550 tons of iron per day, and produces 80,000,000 cu.ft. of gas which passes through the cleaner daily.

The cleaner proper was constructed of reinforced slag concrete due to the scarcity of steel plates during the war. The accompanying photograph shows the cleaner in course of construction. The idea of using concrete for this purpose is quite novel in itself. This structure was built to withstand an explosion pressure of 15 lb. per sq.in., and it is well equipped with explosion valves of special design, which are set to open at 1 lb. pressure per sq.in. The walls, being 15 in. thick, act as a very good insulator to retain the temperature of the gas. The concrete has shown no deterioration, and has withstood all conditions to which it will be subjected, and no trouble is anticipated.

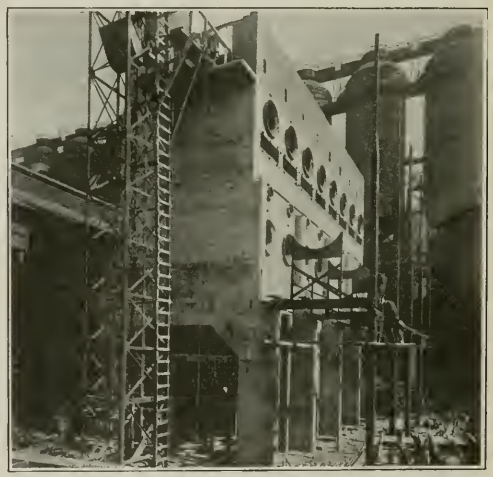
With inquiries favoring steel plate in preference to concrete, the inventors have designed a very adaptable construction which should appeal to the most skeptical. A course of Sil-o-cel insulating brick was used in addition to the regular lining of firebrick in the gas piping, as the idea of retaining the sensible heat in the gases was foremost in the minds of the inventors.

The operation of the cleaner is entirely automatic and does not require constant attendance. One of the men from the regular force maintained in blast-furnace operation inspects and lubricates the machinery once or twice a day.

That the project was well engineered is shown by the fact that the cleaner, when put in operation about two months ago, without any preliminary trials, worked satisfactorily, which is remarkable when considered that it is the first large installation of its kind. This cleaner has been in continuous operation since that time, which demonstrates that it is thoroughly reliable. The power required to operate this cleaner 25 per cent of the time is 4.25 hp., and 75 per cent. of the time 2 hp., making an average power requirement of 2.58 hp. as compared with 80 hp. to 100 hp. for wet washer. The dust is accumulated in hoppers of sufficient capacity to hold two or three days' accumulation. It is then dumped into standard hopper cars, the operation requiring only about one-half hour to remove the dust from the cleaner.

Since this cleaner has been in operation, an additional 25 per cent of dust in the gas leaving the dust catcher has been reclaimed. Heretofore, this was carried away in the water that was used for washing the gas, although it was supposed that very complete settling of the dust was being obtained in large settling basins. The average amount of dust deposited in this cleaner since starting operations is 63,500 lb. per 24 hr., although the gas has previously passed through a dust catcher 30 ft. in diameter. This represents 48.6 per cent of the total dust leaving the furnace by way of the downcomers. The cleaner is maintaining a cleaning efficiency of 90 to 97 per cent, the dust content in clean gas being 0.10 to 0.30 grains per cu.ft. at 62 deg. F.

The range of temperatures of the gases which have passed through this cleaner is 150 to 800 deg. F., and the average loss in temperature due to radiation is 25 deg. F. to 35 deg. F., with atmospheric temperature ranging down to 10 deg. F. There have been instances where the temperature of the outgoing gas has been



DRY GAS CLEANER

150 deg. F. higher than the incoming gas. This is due to a condition where the incoming gas was very low in temperature, the massive concrete walls having stored up the heat from gas of high temperature which previously passed through the cleaner, and giving it up to the gases of low temperature, the structure acting as a heat equalizer.

The resistance to flow or back pressure on the furnace is only 2 to 3 in. water gage. This includes all piping to and from the cleaner, and the cleaner itself. This is considerably lower than the resistance through any type of wet washer. The cleaner is connected to a blast furnace that has been in operation for four years on the present lining, and it has been subjected

to all of the conditions which are characteristic of an old furnace. The cost of an installation for cleaning gas by this method compares very favorably with the cost of a complete wet washing outfit; and considerably less ground space is required, due to the absence of settling basins.

The beneficial results from this method of cleaning are so pronounced that great interest has been shown in the form of inquiries and investigations, and they demonstrate the opportunities which are paramount in the field of dry cleaning furnace gases. During the comparatively short time that this method has been demonstrated, several additional installations have been contemplated at various places, including another cleaner to be built at the Ohio works. Adopting the method of dry-cleaning gas permits other changes in practice that appear on the whole to be very advantageous. By having hot gases enter the hot-blast stoves, it is possible to obtain higher flame temperature in the stoves, which will result in a saving of coke, since a higher hot-blast temperature will be available. It will be possible to operate the furnace with fewer stoves by equipping the stoves with smaller checkers, thereby obtaining better operating efficiency. An installation for cleaning all of the gas from a furnace would cost about the same as a hot-blast stove.

A summary of the advantages to be obtained by the dry cleaning over wet washing of furnace gases is as follows:

Sensible heat of the gas is retained.
When burned under boilers, the gas generates more steam.
When burned in hot-blast stoves, produces higher blast temperature.
No water is required for cleaning the gas.
No settling basins are required.
Less ground space required, due to absence of settling basins.
No pollution of streams.
Less labor cost in handling the dust.
Less than one-tenth the power required to operate.
Less back pressure on the furnace.
Cleaning efficiency as good as the best types of wet washers.
No sludge dripping from gas mains and burners.

Book Reviews

MILL AND CYANIDE HANDBOOK. By *A. W. Allen.* 128 pages, with diagrams and charts; price $2.00. Philadelphia: J. B. Lippincott Co.

This addition to the many handbooks recently issued has been planned to cover a narrow field. Its subject matter is devoted to the winning of the precious metals by amalgamation and cyanidation. The book is of English origin. It typifies English methods and draws its material largely from English sources. For instance, its tables consist in considerable part of data from South African practice, and thus may be explained the complete absence of concentration and of flotation data. From the American viewpoint, this circumstance is at once a strength and a weakness of the book—the one since it brings the reader useful data not easily available, the other by its inclusion of the conversion tables for English moneys and measures.

To readers of the technical press, who have known the author as a writer of exceptionally precise expression and of thorough acquaintance with his subject, the first impression of the book is distinctly disappointing. Closer examination discloses much useful matter, but this impression is never wholly dissipated. Criticism is somewhat disarmed by the author's statement that the data were collected prior to 1914. The book seems to lack systematic arrangement—a fault perhaps more of the publisher than of the author—and the matter is of unequal merit. The presentation of all data in tabular or graphic form is novel and is doubtless the logical method for a book of this class. The style offers some difficulties, as for instance in the description of assay methods, and it tempts to the expansion into a table of what could as well be compressed into a single line. Thus the weight of sheet-lead is readily derived from the weight of a unit volume of this material. Again, the matter in Section 5 could have been expressed more simply without loss.

The launder data—page 62—are insufficient. The general formulæ, as of Blue and Caldecott, are not given, and the valuable data of Washoe and Cananea, published a few years ago in the *Engineering & Mining Journal*, are missing. We find nothing of cyanide antidotes, or of volumes of conical classifiers, and not enough of weights of materials or of hydraulic equivalents.

The author's excellent formulæ for the calculation of extraction and of recovery are given. It is to be regretted that he deemed the scope of the book insufficient to include Hoover's formulæ for concentration. The tabular matter is followed by a series of typical flow-sheets, useful for reference, and these by a group of report-forms of rather doubtful value. An excellent glossary closes the volume.

Personal

Mr. Robert J. Anderson has resigned as research metallurgist with the Bureau of Aircraft Production, Detroit, and will join the staff of the Bureau of Mines. He will make special investigation in the metallurgy of aluminium and other non-ferrous metals, at the experiment station at Pittsburgh.

Major Charles V. Bacon, who was engaged during the war on investigation relating to liquid fire and war gas, has been made chief of the Research Section of the Engineering and Standardization branch P. S. & T. division of the General Staff.

Capt. C. L. Colburn has returned from service with the Corps of Engineers, and has resumed his former work as assistant metal mining engineer for the Bureau of Mines, stationed in Washington.

Dr. Henry M. Howe is to sail for Europe early in April for a stay of about three months.

Mr. Walter Renton Ingalls, editor of *Engineering & Mining Journal* for nearly 14 years, has resigned to reenter professional practice as a consulting engineer, with offices at 115 Broadway, New York City.

Dr. A. D. Little recently addressed the Industrial Association in Cleveland on the industrial utilization of chemical research.

Mr. Dorsey A. Lyon, supervisor of stations for the Bureau of Mines, is on an extended Western trip of inspection.

Capt. A. C. Nell, Construction Division, U. S. A., has been released from active duty in the Army, and has been appointed Chicago district manager for the Lea-Courtenay Co. and the Schutte & Koerting Co.

Mr. H. C. Parmelee, editor of Chemical & Metallurgical Engineering, has been appointed acting editor of the *Engineering & Mining Journal*, vice Mr. Walter Renton Ingalls, resigned.

Mr. F. R. Still, vice-president and secretary of the American Blower Co., has left on an extended trip for the Far East, where he will investigate trade conditions in connection with export work. His itinerary includes Japan, China, Australia and most of the European countries.

Dr. T. B. Wagner, chief chemist of the Corn Products Refining Co., New York City, has resigned to take a similar position with the United States Food Products Corp., 40 Exchange Pl., New York City, which has lately succeeded to the business of what was formerly known as the Distillers Securities Corporation.

Current Market Reports

The Non-Ferrous Metal Market

Monday, March 24. — Prices on the non-ferrous metal market are inviting to buyers and large transactions are impending.

Aluminium:—Conditions are unusually quiet, as aluminium has not declined. Ingots 98-99 per cent, 31c. lb. Sheets, 18 gage and heavier, 42c. Powder, 0.70-1.40 lb.

Antimony: — Wholesale lots are offered from 7c. to 7⅛c. and jobbing at 7¼c. There is no active buying.

Copper: — No sustained buying has taken place, with prices as low as 15c. lb.

Copper sheets, hot-rolled	lb.	$0.22½—
Copper sheets, cold rolled	lb.	.23½—
Copper bottoms	lb.	.30½—
Copper rods	lb.	.19½—
Copper wire	lb.	.18 —
High brass wire and sheets	lb.	.18½—
High brass rods	lb.	.17½—
Low brass wire and sheets	lb.	.18½—
Low brass rods	lb.	.21½—
Brazed brass tubing	lb.	.29½—
Brazed bronze tubing	lb.	.33½—
Seamless copper tubing	lb.	.28 —
Seamless bronze tubing	lb.	.29½—
Seamless brass tubing	lb.	.30 —
Bronze (gold) powder	lb.	1 00 —

Lead: — No change has occurred with lead. East St. Louis quotes 4.90-5.00c. per lb. and New York 5¼c. Sheet lead, 8-8¾c. lb.

Tin: — The fixed price of 72½c. will remain until the 10,000-ton allotment is liquidated, which will be from sixty to ninety days yet.

Zinc: — Spelter remains unchanged, with East St. Louis prices showing no future decline from $123.50 per ton. Zinc dust, 14c. Sheet zinc, 11c. lb.

OTHER METALS

Bismuth	lb.	$3.20 — $3.65
Cadmium	lb.	1.40 — ....
Cobalt	lb.	2.50 — 3.50
Magnesium	lb.	1.75 — 2.10
Mercury	75 lb.	68.00 — ....
Nickel	lb.	.40 — .45
Tungsten	lb.	Nominal
Iridium	oz.	175.00 — .....
Palladium	oz.	115.00 —
Platinum	oz.	95 00 —100.00
Silver	oz.	1 01⅛— .....

The Iron and Steel Market

A wide variety of opinion has been expressed on the price reductions made in pig iron, unfinished steel and finished steel products as a result of the activities of the Industrial Board of the Department of Commerce. This board, the conception and creation of Secretary of Commerce Redfield, undertook to deflate commodity prices, particularly those involved in construction work, for the purpose of stimulating business activity. As noted in last report, at a meeting of iron and steel purchasers March 6 there was a unanimous vote to co-operate with the board. A meeting between the industry's committee and the board was arranged for March 12, but was postponed one week. When the two bodies met, Wednesday morning, March 19, the producers' committee did not have a schedule of prices and asked for time to deliberate further, stating it would meet the board in the afternoon. Later it asked that the meeting be deferred until the following morning. It was not ready then, and it was not until 11.45 Thursday night that a partial schedule was completed. The producers put the reduced prices in effect as of the following morning, the precise time being important inasmuch as invoice prices of shipments of much finished steel hinged upon the price, the producers being disposed, according to trade custom, to give customers the advantage of any market declines.

Since the new prices were announced there has been some criticism of them by producers, though not a great deal, the disposition being to make the best of the situation. The adjustment may better be judged by opinions freely expressed in the trade before the new prices were formulated. There was then expressed very widely the opinion that steel prices should not be cut at all, or should be cut deeply. No small reduction, it was urged, at all comparable to the reduction of last December would do any good. A small reduction would cause the steel mills to receive less money for deliveries against orders already on books, while it would not stimulate or increase consumption. These utterances have proved unfortunate, since that is precisely the kind of a reduction that has been made. Members of the committee have been indisposed to divulge the nature of the discussions that kept them so long in reaching a conclusion, but one may perhaps guess that what was done represented a compromise between counsel for no reduction and counsel for a large reduction. The matter had been so widely advertised, and buyers were so generally holding back orders in anticipation of reductions that something had to be done.

Extent of Reductions

The reductions made were as follows: Pig iron, $4.25 per gross ton; unfinished steel, $5 per gross ton; wire products and grooved steel skelp, $5 per net ton; all other rolled steel products, $7 per net ton. The trade adopts the practice of applying the $4.25 reduction to the last Government prices, allowing for the $3 reduction previously made. War Industries Board extras, differentials, basings, etc., are to obtain. Obviously this will not work out for any length of time, since the furnacemen are not used to such an artificial price structure, nor indeed can it be fully maintained. The price of No. 2 foundry iron would be the same, $26.75, f.o.b. valley furnaces, Ironton furnaces, Chicago furnaces and Birmingham furnaces, and Birmingham could not reach a sufficient market, on account of freights. Immediately one small divergence occurred. More or less by chance, apparently, malleable iron had been set, under Government control, at 50c. above foundry iron, while foundry iron was $1 above basic. Normally much of the malleable iron produced is simply off basic. Immediately upon the announcement of the new prices a prominent valley furnace interest offered to sell malleable at 50c. above basic, which would be 50c. below foundry instead of 50c. above.

The new prices on unfinished steel are: Billets, $38.50; 2-inch billets, $42; sheet bars, $42; slabs, $41; rods, $52. All these products had been reduced $4 in December, except rods, which were not reduced. The new finished steel prices, in cents per pound, are: Bars, 2.35c.; shapes, 2.45c.; plates, 2.65c.; grooved steel skelp, 2.45c.; universal mill skelp, 2.55c.; sheared skelp, 2.65c.; merchant steel pipe, 57½ per cent basing discount; plain wire, 3c.; wire nails, $3.25 per keg; black sheets, 28 gage, 4.35c.; blue annealed sheets, 10 gage, 3.65c.; galvanized sheets, 28 gage, 5.70c.; tin plate, $7 per base box, 100-pound.

Price Comparisons

No. 2 foundry pig iron was $33 under Government control, advancing to $34 by the settlement late in September, 1918, becoming $30 about Jan. 1, 1919, and now declining to $26.75, basic iron being $1 less, while bessemer is $27.95. Foundry iron at valley furnaces 1904 to 1913 inclusive averaged $15.68. The ten-year pre-war average in billets was $24.82, the Government price being $47.50, while the present price is $38.50. A weighted average of bars, shapes, plates, pipe, wire products, sheets and tin plates shows the following, per net ton: Ten-year pre-war average, $36; Government limit, $76; after December reductions, $72; after March reductions, $65. Thus prices remain above the pre-war average as follows: Pig iron, 71 per cent; billets, 55 per cent; finished steel, 81 per cent.

Market Prospects

Both official statements on the price adjustment, that of Judge Gary, chairman of the producers' committee, and that of the Industrial Board, state in substance that the new prices are to be minimum for the remainder of the year. If, however, the price reduction does not greatly stimulate consumption the way will be open for a further consideration of the subject, say in June or September. The experience of the first few weeks after these reductions will not prove sufficient for a long range prediction. Buyers were making purchases only from hand to mouth, but even under that policy they were able to hold back orders for a short time, when they saw the prospect of reductions being

made. As the new prices would in any event hold for a time, buyers who are supplying ordinary everyday requirements are naturally buying freely and the market is moderately active. The rate of steel production, which was 85 per cent in January and only a shade less in February, had declined in March, but will probably hold at about 75 per cent for a while.

The investment buyer, on the other hand, cannot be heard from at once and it will require some time to observe how he takes the reduction. The investor, furthermore, considers other materials than steel, including lumber, brick, cement, etc. These and other commodities are still to be taken in hand by the Industrial Board and the investor will be disposed to wait and see what luck the board has with these commodities. Thus the real test of the new steel prices can hardly occur within the next month or two.

The steel trade has accepted the new arrangement as distinctly a price maintenance one. with support by the Industrial Board and absolution of the Department of Justice, with which department there was close contact during the negotiations. There is, however, an important divergence between the situation now and that which obtained during the price maintenance of 1908. At that time distribution of orders was arranged whereby all producers operated at substantially the same rate and thus there were no jealousies. In the past few weeks there has been a wide divergence in the rates at which the various producers have operated.

The Chemical Market

Coal-Tar Products.—The situation in general has undergone no material change in the interim. While at this writing a firmer tendency prevails in the crudes, with buyers showing more interest than formerly and weak sellers fairly well cleaned out, the intermediates have not followed suit and if anything they are weaker than formerly, although quoted prices are about the same. The reason for the weakness in price of the intermediates is attributed in the main to the fact that more concerns are producing with unusually large quantities of surplus material on the market. Buyers, on the other hand, have not increased, and in fact have decreased, and those who were accustomed to laying in large stocks to bridge over eventualities find it unnecessary to do so while conditions continue as they are.

Phenol:—This market has firmed up considerably due to the elimination of several second hands who were holding large quantities for foreign governments. The inquiry has improved and though there are not as many large sales being closed as formerly, the volume of comparatively small sales is quite satisfactory in the aggregate.

Benzol:—It is still possible to shade producers' prices, due to the fact that large quantities are held in second hands, but prices are in the main well maintained in both quarters. A fair volume of business is passing, although the former tendency on the part of buyers to stock up for long periods has abated somewhat, and in most quarters they are buying only sufficient to cover for present requirements.

Toluol:—Buyers are displaying more interest than they have for some time past. Material is for the most part held by producers, with only limited quantities available in second hands, so that there is but little business passing through the latter hands and prices are on a firmer basis.

Naphthaline:—There is not a great deal of business passing in this item. Consumers appear to be indisposed to stock up for more than immediate requirements and the volume of business closed is not as great as sellers would like to see. Prices are, as a result, considerably easier.

Aniline Oil:—Large quantities of this material are available at present with only a moderate demand and some marked concessions in price have resulted. While producers are not generally inclined to reduce quoted prices, firm bids at less than quoted prices have been accepted.

Aniline Salt:—The increased output has resulted in a weaker position and in the desire to move material low prices have been accepted in several instances.

Paranitraniline:—A fairly active business is passing, but there are several concerns producing, with surplus stocks on the market and prices lower.

Salicylic Acid:—With little or no demand prevailing and large quantities on the market, prices are considerably lower.

Benzoate of Soda:—Both the soda and acid have felt the effect of curtailment of export demand and lower prices are in order as a result.

Salol:—The demand is not pressing and though there are sales of moderate quantities passing, the position is anything but firm.

Dimethylaniline:—Business is passing in fair volume but is considerably less than dealers can take care of, and despite attractive prices buyers are seemingly not greatly interested.

Anthracene:—A fairly active demand prevails, and with only a few producers in the field prices are fairly well maintained.

Resorcin:—The production is confined to a few quarters, with an active demand and prices unchanged.

Heavy Chemicals.—Despite the fact that inducements in the way of what are considered attractive prices, buyers are seemingly disinclined to contract over long periods, or to buy more than sufficient material to cover current requirements. As a result, there is considerable gunning for business on the part of large producers and prices have, in a great many instances, been shaded in an endeavor to move surplus stocks. Such large business as is passing is generally confined to the filling of export orders, but even this avenue of consumption is considerably clogged up due to the present harbor strike and the resultant difficulty in moving material so that it will reach the vessels by sailing time. There is also considerable difficulty encountered in getting buyers on old contracts to accept material due to the drop in price.

Caustic Soda:—Compared with the few weeks preceding, the past week has seen some improvement in the volume of trading. Prices, however, have weakened, if anything, due to liberal offerings and the keen competition prevailing among the many holders. Sales of material f.a.s. have been made in exceptional cases as low as $2.60, although $2.70 to $2.75 is more representative of the prices prevailing in most instances. Material ex-warehouse sold at $2.55 to $2.60 on the average. A sale of a goodly quantity of resale material threatened, for a time, to have a disturbing effect, but it was subsequently withdrawn from the market.

Soda Ash:—Although some very liberal inducements are made to buyers, they do not appear to be inclined to buy heavily, and such business as is passing is for very small quantities. The general outlook based upon conditions prevailing the past few weeks appears to have a depressing effect on the market. Sales were made ex-warehouse in bags at $1.55 to $1.60.

Bleaching Powder:—The arrival of large quantities on the market, with such buying interest as there is confined to export orders and these not heavy, has caused an easier price position, although quotations in general are unchanged. Export drums are available at $2.25, with domestic drums at $1.60 to $1.65.

Copper Sulphate:—Comparatively large sales are being closed and it is possible to shade prices in a great many instances. From $7.15 to $7.25 is quoted for outside brands, with standard brands somewhat higher.

Formaldehyde:—There is an active business passing in this item, but stocks are ample and sales have been closed at 22c. in the past week.

Sodium Sulphide:—Buying pressure is not heavy and sales are passing here and there at a shade under former prices.

Nitrate of Soda:—There are only small lots of 25 to 50 tons in all that are available on the resale market, at $4.05 to $4.07½. The Government-fixed price of $4.07½ continues to be maintained.

Glycerine:—The bulk of sales passing is for small quantities, and prices are somewhat lower.

Calcium Carbide:—There is only a moderate volume of business passing and from time to time concessions in price are made, with 6¼c. to 6½c. quoted.

Arsenic:—Such sales as are passing are for comparatively small quantities. The white material, which is in fair demand, is quoted at 9c. to 9¼c. The red is quite neglected, with 26c. to 31c. quoted.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET MARCH 24, 1919

Acetic anhydride	lb.	.90	—	1.00
Acetone	lb.	.15½	—	.16
Acid, acetic, 28 per cent	cwt.	3.25	—	3.40
Acetic, 56 per cent	cwt.	6.50	—	6.75
Acetic, glacial, 99½ per cent, carboys	cwt.	14.00	—	14.50
Boric, crystals	lb.	.13½	—	.15
Citric, crystals	lb.	1.25	—	1.25½
Hydrochloric, (22%)	cwt.	2.50	—	3.00
Hydrofluoric, 30 per cent, in barrels	lb.	.08	—	.08½
Lactic, 44 per cent	lb.	.15	—	.16
Lactic, 22 per cent	lb.	.06	—	.07
Molybdic, C. P	lb.	6.90	—	7.40
Nitric, 36 deg	lb.	6.60	—	6.85
Nitric, 42 deg	lb.	.08½	—	.10
Oxalic, crystals	lb.	.32	—	.34
Phosphoric, 47-50 per cent paste	lb.	.07½	—	.10
Phosphoric, ref. 50 per cent	lb.	.26	—	.30
Picric	lb.	.50	—	.75
Pyrogallic, resublimed	lb.	2.70	—	3.20
Sulphuric, 60 deg. works	ton	12.00	—	14.00
Sulphuric, 66 deg. works, tank cars	ton	17.00	—	25.00
Sulphuric, oleum (fumitg), tank cars	ton	25.00	—	26.00
Tannic, U. S. P., bulk	lb.	1.40	—	1.50
Tartaric, crystals	lb.	.86½	—	.87
Tungstic, per lb. of W	lb.	1.60	—	1.75
Alcohol, sugar cane, 188 proof	gal.	4.91	—	.....
Alcohol, wood, 95 per cent	gal.	1.28	—	1.30
Alcohol, denatured, 180 proof	gal.	.40	—	.42
Alum, ammonia lump	lb.	.04½	—	.05½
Alum, chrome ammonium	lb.	.17½	—	.18
Alum, chrome potassium	lb.	.20	—	.22
Alum, chrome sodium	lb.	.12½	—	.13
Alum, potash lump	lb.	.10	—	.12
Aluminium sulphate, technical	lb.	.02	—	.02½
Aluminium sulphate, iron free	lb.	.03	—	.03½
Ammonia aqua, 26 deg., carboys	lb.	.07	—	.08½
Ammonia, anhydrous	lb.	.30	—	.35
Ammonium carbonate	lb.	.13	—	.14
Ammonium nitrate	lb.	.16	—	.17
Ammonium sulphate, domestic	lb.	.05½	—	.05½
Amyl acetate	gal.	3.50	—	3.75
Arsenic, white	lb.	.09½	—	.10
Arsenic, red	lb.	.35	—	.40
Barium carbonate, 99 per cent	ton	80.00	—	90.00
Barium carbonate, 97-98 per cent	ton	65.00	—	67.00
Barium chloride	ton	70.00	—	80.00
Barium sulphate (blanc fixe, dry)	lb.	.03½	—	.04
Barium nitrate	lb.	.10	—	.11
Barium peroxide, basis 70 per cent	lb.	.30	—	.32
Bleaching powder, 35 per cent chlorine	lb.	.01½	—	.02½
Borax, crystals, sacks	lb.	.07½	—	.08½
Brimstone, crude	ton	28.00	—	35.00
Bromine, technical	lb.	.55	—	.60
Calcium acetate, crude	lb.	.04	—	.05
Calcium carbide	lb.	.06½	—	.06½
Calcium chloride, 7-75 per cent, fused, lump	ton	18.00	—	22.00
Calcium peroxide	lb.	1.50	—	1.70
Calcium phosphate	lb.	.22	—	.23
Calcium sulphate, 98-99 per cent	lb.	.09	—	.09½
Carbon bisulphide	lb.	.07	—	.08
Carbon tetrachloride, drums	lb.	.14	—	.15
Carbonyl chloride (phosgene)	lb.	.75	—	1.00
Caustic potash, 88-92 per cent	lb.	.50	—	.60
Caustic soda, 76 per cent	100 lb.	2.60	—	2.75
Chlorine, liquid	lb.	.10	—	.12
Cobalt oxide	lb.	1.60	—	1.65
Copperas	lb.	.01½	—	.02½
Copper carbonate	lb.	.31	—	.32
Copper cyanide	lb.	.65	—	.70
Copper sulphate, 99 per cent, large crystals	lb.	7.15	—	7.50
Cream of tartar, crystals	lb.	.55	—	.58
Epsom salt, bags, U. S. P	100 lb.	2.75	—	.....
Formaldehyde, 40 per cent	lb.	.22	—	.22½
Glauber's salt	lb.	.02	—	.02½
Glycerine, bulk, C.P	lb.	.17½	—	.18
Iodine, resublimed	lb.	4.25	—	4.30
Iron oxide	lb.	.06	—	.08
Lead acetate, white crystal	lb.	.12½	—	.14
Lead arsenate (paste)	lb.	.15	—	.18
Lead nitrate, C. P	lb.	.85	—	.86
Litharge, American	lb.	.10	—	.11
Lithium carbonate	lb.	1.50	—	.....
Magnesium carbonate, technical	lb.	.16	—	.17
Nickel salt, single	lb.	.14	—	.15
Nickel salt, double	lb.	.12	—	.13
Phosgene (see carbonyl chloride)	lb.	.75	—	1.00
Phosphorus, red	lb.	.75	—	.80
Phosphorus, yellow	lb.	.35	—	.40
Potassium bichromate	lb.	.37	—	.38
Potassium bromide, granular	lb.	1.25	—	1.26
Potassium carbonate, calcined, 85-90 per cent	lb.	.17	—	.18
Potassium chlorate, crystals	lb.	.39	—	.41
Potassium cyanide, 98-99 per cent	lb.	2.50	—	2.75
Potassium iodide	lb.	3.75	—	3.80
Potassium muriate, 80-85 p. c. basis of 80 p. c.	ton	200.00	—	250.00
Potassium nitrate	lb.	.26	—	.30
Potassium permanganate, U. S. P	lb.	.80	—	.82
Potassium prussiate, red	lb.	1.50	—	1.60
Potassium prussiate, yellow	lb.	.55	—	.58
Potassium sulphate, 90-95 p. c. basis 90 p. c.	ton	Nominal		
Rochelle salts	lb.	.46½	—	.48
Salammoniac, gray gran	lb.	.14	—	.16
Salammoniac, white gran	lb.	.12½	—	.13
Sal soda	100 lb.	1.60	—	2.00
Salt cake	ton	20.00	—	22.00
Silver cyanide, based on market price of silver	oz.	.....		.....
Silver nitrate	oz.	.62½	—	.63½
Soda ash, 58 per cent, light, flat (bags)	100 lb.	1.55	—	1.60
Soda ash, 58 per cent, dense, flat	100 lb.	2.45	—	3.00
Sodium acetate	lb.	.07½	—	.08
Sodium bicarbonate, domestic	lb.	.02½	—	.03
Sodium bicarbonate, English	lb.	.....		.....
Sodium bichromate	lb.	.12	—	.14
Sodium bisulphite, powd	lb.	.05	—	.07
Sodium chlorate	lb.	.16	—	.18
Sodium cyanide	lb.	.30	—	.31
Sodium fluoride, commercial	lb.	.14	—	.15
Sodium hyposulphite	100 lb.	3.25	—	3.75
Sodium molybdate, per lb. of Mo	lb.	2.50	—	.....
Sodium nitrate, 95 per cent	100 lb.	4.07½	—	.....
Sodium nitrite	lb.	.13	—	.14
Sodium peroxide	lb.	.25	—	.30
Sodium phosphate	lb.	.03½	—	.03½
Sodium prussiate, yellow	lb.	.22	—	.24
Sodium silicate, liquid (60 deg.)	lb.	.05	—	.05½
Sodium sulphide, 30 per cent, crystals	lb.	.02	—	.02½
Sodium sulphide, 60 per cent, fused	lb.	.04½	—	.05
Sodium sulphite	lb.	.05½	—	.06½
Strontium nitrate	lb.	.25	—	.30
Sulphur chloride, drums	lb.	.07½	—	.09
Sulphur dioxide, liquid, in cylinders	lb.	.12	—	.15
Sulphur, flowers, sublimed	100 lb.	3.05	—	3.15
Sulphur, roll	100 lb.	2.70	—	3.10
Sulphuric, crude	ton	35.00	—	37.50
Tin bichloride, 50 deg	lb.	.27½	—	.28
Tin oxide	lb.	.65	—	.70
Zinc carbonate	lb.	.18	—	.20
Zinc chloride	lb.	.14	—	.14½
Zinc cyanide	lb.	Nominal		
Zinc dust, 350 mesh	lb.	.12	—	.13
Zinc oxide, American process, works	lb.	.10	—	.12
Zinc sulphate	lb.	.03½	—	.04

Coal Tar Products (Crude)

Benzol, pure, water white	gal.	.20	—	.25
Benzol, 90 per cent	gal.	.25	—	.....
Toluol, in tank cars	gal.	.25	—	.....
Toluol, in drums	gal.	.30	—	.35
Xylol, pure, water white	gal.	.45	—	.55
Solvent naphtha, water white	gal.	.20	—	.25
Solvent naphtha, crude, heavy	gal.	.15	—	.17
Creosote oil, 25 per cent	gal.	.45	—	.55
Dip oil, 20 per cent	gal.	.40	—	.45
Pitch, various grades	ton	8.00	—	20.00
Carbolic acid, crude, 95-97 per cent	lb.	Nominal		
Carbolic acid, crude, 50 per cent	lb.	Nominal		
Carbolic acid, crude, 25 per cent	lb.	Nominal		
Cresol, U. S. P	lb.	.18	—	.20

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00	—	1.10
Alpha naphthol, refined	lb.	1.20	—	1.25
Alpha naphthylamine	lb.	.45	—	.50
Aniline oil, drums extra	lb.	.24	—	.25
Aniline salts	lb.	.36	—	.40
Anthracene, 80 per cent	lb.	.50	—	.55
Benzaldehyde (f.f.c.)	lb.	2.50	—	2.60
Benzidine, base	lb.	1.00	—	1.15
Benzidine, sulphate	lb.	.95	—	1.00
Benzoic acid, U. S. P	lb.	1.20	—	1.25
Benzoate of soda, U. S. P	lb.	1.20	—	1.25
Benzyl chloride	lb.	.50	—	.....
Beta naphthol benzoate	lb.	5.50	—	6.00
Beta naphthol, sublimed	lb.	.55	—	.65
Beta naphthylamine, sublimed	lb.	2.50	—	2.55
Dichlorbenzol	lb.	.15	—	.20
Diethylaniline	lb.	2.25	—	2.75
Dinitrobenzol	lb.	.30	—	.35
Dinitrochlorbenzol	lb.	.30	—	.35
Dinitronaphthaline	lb.	.50	—	.55
Dinitrotoluol	lb.	.40	—	.50
Dinitrophenol	lb.	.38	—	.40
Dimethylaniline	lb.	.55	—	.60
Diphenylamine	lb.	.70	—	.75
H-acid	lb.	2.35	—	2.75
Metaphenylenediamine	lb.	1.55	—	1.75
Monochlorbenzol	lb.	.15	—	.17
Naphthalene, flake	lb.	.07	—	.08
Naphthalene, balls	lb.	.10½	—	.11½
Naphthionic acid, crude	lb.	1.20	—	1.30
Naphthylamin-di-sulphonic acid	lb.	1.00	—	1.10
Nitro naphthaline	lb.	.40	—	.45
Nitro toluol	lb.	.55	—	.60
Ortho-amidophenol	lb.	6.00	—	7.00
Ortho-dichlor-benzol	lb.	.15	—	.20
Ortho-toluidine	lb.	.45	—	.50
Ortho-nitro-toluol	lb.	.45	—	.50
Para-amidophenol, base	lb.	3.25	—	3.65
Para-amidophenol, H. C. L	lb.	3.50	—	3.75
Para-dichlor-benzol	lb.	.15	—	.20
Paranitraniline	lb.	1.25	—	1.35
Para-nitro-toluol	lb.	1.50	—	1.60
Paraphenylenediamine	lb.	3.25	—	3.50
Para toluidine	lb.	1.80	—	1.85
Phthalic acid anhydride	lb.	2.50	—	3.00
Phenol, U. S. P	lb.	Nominal		
Resorcin, technical	lb.	4.50	—	5.00
Resorcin, pure	lb.	7.00	—	8.00
Salicylic acid, U. S. P	lb.	.35	—	.40
Salol	lb.	.95	—	1.00
Sulphanilic acid, crude	lb.	.25	—	.31
Toluidine	lb.	2.45	—	.....
Toluidine-mixture	lb.	.80	—	1.00

Petroleum Oils

Crude (at the Wells)

Pennsylvania	bbl.	4.00	—	.....
Corning, Ohio	bbl.	2.85	—	.....
Somerset, Ky	bbl.	2.60	—	.....
Wooster, Ohio	bbl.	2.85	—	.....
Indiana	bbl.	2.28	—	.....
Illinois	bbl.	2.25	—	.....
Oklahoma and Kansas	bbl.	2.25	—	.....
Caddo, La., light	bbl.	2.10	—	2.25
Corsicana, Tex., light	bbl.	2.25	—	.....
California	bbl.	1.24	—	1.57
Gulf Coast	bbl.	1.25	—	1.30
Mexican	bbl.	1.90	—	.....

Fuel Oil

New York	gal.	.15	—	.....
Philadelphia	gal.	.10½	—	.....
Baltimore	gal.	.07½	—	.15
Pittsburgh	gal.	.07½	—	.10½
Texas	bbl.	1.85	—	2.10
Los Angeles	bbl.	1.65	—	.....

Gasoline (Wholesale)

New York, motor	gal.	.24½	—	.....
Gas machine	gal.	.41½	—	.....
72-76 degrees	gal.	.33½	—	.39½
70-72 degrees	gal.	.32	—	.37½
67-70 degrees	gal.	.30½	—	.36½
Pittsburgh, motor	gal.	.24½	—	.....
Chicago, motor	gal.	.23	—	.....
Oklahoma, motor	gal.	.23½	—	.....
San Francisco, motor	gal.	.20½	—	.....

Paraffine Waxes

Crude, 103 to 105 deg. m.pt	lb.	.08½	—	.09
Crude, 118 to 120 deg. m.pt	lb.	.09½	—	.10
Crude, 124 to 126 deg. m.pt	lb.	.10	—	.....
Refined, 120 deg. m.pt	lb.	.12	—	.12½
Refined, 128 deg. m.pt	lb.	.14	—	.....
Refined, 135 deg. m.pt	lb.	.15	—	.15½
Refined 140 deg. mp	lb.	.17½	—	.....
Ozokerite, green	lb.	.85	—	.90

Lubricants

Black, reduced, 29 gravity, 25-30 cold test	gal.	.20	—	.30
Cylinder, light	gal.	.38	—	.42
Cylinder, dark	gal.	.39	—	.43
Paraffine, high viscosity	gal.	.40	—	.41
Paraffine, 0.903 sp. gr	gal.	.32	—	.33
Paraffine, 0 865 sp. gr	gal.	.29	—	.35

Flotation Oils

(Prices at New York unless otherwise stated)

Pine oil, crude, f. o. b. Florida	gal.	.44	—	.....
Pine oil, steam distilled, sp. gr. 0.925-0.940	gal.	.58	—	.60
Pine oil, destructively distilled	gal.	.58	—	.60
Pine-tar oil, sp. gr. 1.02-1.035	gal.	.35	—	.....
Pine-tar oil, double refined, sp. gr. 0.965-0.990	gal.	.42	—	.....
Pine-tar oil, ref., light, sp. gr. 0.950, tank cars, f.o.b. works	gal.	.37	—	.....
Pine-tar oil, ref., heavy, sp. gr. 1.025, tank cars, f.o.b. works	gal.	.28	—	.....
Pine-tar oil, ref., thin, sp. gr., 1.060-1.080	gal.	.32	—	.....
Turpentine, crude, sp.gr. 0.870-0.900	gal.	.45	—	.....
Hardwood oil, f.o.b. Michigan, sp.gr. 0.960-0.990	gal.	.23	—	.....
Hardwood oil, f.o.b. Michigan, sp.gr. 1.06-1.08	gal.	.23	—	.....
Wood creosote, ref., f.o.b. Florida	gal.	.31	—	.....

Naval Stores

Rosin A-E barrel	280 lb.	12.20	—	12.30
Rosin F-I	280 lb.	12.35	—	12.80
Rosin K-N	280 lb.	13.50	—	14.50
Rosin WG-W	280 lb.	15.25	—	15.50
Spirits of turpentine	gal.	.75	—	.....
Wood turpentine, steam distilled	gal.	.64	—	.65
Wood turpentine, destructively distilled	gal.	.63	—	.65½
Pitch	bbl. 220 lb.	8.00	—	.....
Tar, kiln dried	280 lb.	13.00	—	13.50
Retort tar	280 lb.	14.00	—	14.50
Rosin oil, first run	gal.	.74	—	.....
Second run	gal.	.76	—	.....
Third run	gal.	.82	—	.....
Fourth run	gal.	.92	—	.....

Vegetable Oils

Castor oil	lb.	.21	—	.29
China wood oil	lb.	.19	—	.21
Cocoanut oil	lb.	.12½	—	.18
Corn oil	lb.	.13	—	.17
Cottonseed oil, crude	lb.	.17½	—	.22
Linseed oil, raw, cara	gal.	1.50	—	1.53
Palm	lb.	.14½	—	.23½
Peanut oil, crude	lb.	.14½	—	.21
Soya bean oil, Manchuria	lb.	.12½	—	.16

Glues

Extra white	lb.	.35	—	.40
Cabinet	lb.	.25	—	.26
Brown foot stock	lb.	.15	—	.19
Fish glue, 50-gal. barrels	gal.	1.00	—	1.50

Miscellaneous Materials

Barytes, floated, white domestic	ton	33.00	—	36.00
Beeswax, white, pure	lb.	.63	—	.65
Beeswax, unbleached	lb.	.40	—	.48
Blanc fixe	lb.	.05½	—	.....
Casein	lb.	.18	—	.22
Chalk, light, precipitated, English	lb.	.04½	—	.06
China clay, imported, lump	ton	20.00	—	40.00
China clay, domestic, lump	ton	15.00	—	22.50
Feldspar	ton	8.00	—	12.00
Fluorspar, gravel, f. o. b. mines	ton	25.00	—	32.00
Fluorspar, washed, powdered	ton	90.00	—	.....
Fuller's earth, powdered	100 lb.	1.50	—	2.00
Graphite Alabama	lb.	.08	—	.12
Ceylon	lb.	.09	—	.22
Madagascar	lb.	.10	—	.15
Mexican	ton	35.00	—	75.00
Japan wax	lb.	.12	—	.14
Orange shellac	lb.	.49	—	.64
Pumice stone	lb.	.04	—	.08
Soapstone	ton	.12	—	.17
Stearic acid	lb.	.17	—	.19½
Talc, American, white	ton	20.00	—	40.00

Refractories, Etc.

(F.O.B. Works)

Chrome brick	net ton	100.00	—	120.00
Chrome cement	net ton	65.00	—	.....
Clay brick, first quality firecla	per 1000	40.00	—	47.00
Clay brick, second quality	per 1000	35.00	—	40.00
Magnesite, raw	ton	30.00	—	35.00
Magnesite, calcined, powdered	ton	50.00	—	65.00
Magnesite, dead burned	net ton	38.00	—	40.00
Magnesia brick, 9x4½x2½	net ton	90.00	—	.....
Silica brick	per 1000	45.00	—	55.00

Ferroalloys

Ferrocarbontitanium, 15-18 per cent, carloads, f. o. b. Niagara Falls, N. Y.	ton	200.00	—	250.00
Ferrocerium	lb.	15.00	—	30.00
Ferrochromium, per lb. of Cr.	lb.	.30	—	.40
Ferromanganese, domestic, 70 per cent basis	ton	150.00	—	.....
Spielgeleisen (16-18%)	ton	45.00	—	50.00
Ferromolybdenum, per lb. of Mo	lb.	3.50	—	4.50
Ferrosilicon, 50 per cent, contract	ton	120.00	—	125.00
Ferrotungsten, 75-85 per cent, f.o.b. Pittsburgh	lb.	Nominal		
Ferrouranium, f.o.b. works, per lb. of U	lb.	7.50	—	.....
Ferrovanadium, f.o.b. works	lb.	.....	—	.....

Ores and Semi-finished Products

Chrome ore, 35%, per unit	ton	.80	—	.....
Chrome, Caledonia, 50%, per unit	ton	1.00	—	.....
Coke	ton	6.00	—	7.00
Petroleum coke	ton	16.00	—	.....
Manganese ore, 48 per cent and over, per unit	ton	1.20	—	.....
Manganese ore, chemical	ton	75.00	—	85.00
Molybdenite, per lb. of MoS_2	lb.	.75	—	.85
Tungsten, Scheelite, per unit of WO_3	ton	10.00	—	12.00
Tungsten, Wolframite, per unit of WO_3	ton	7.00	—	9.00
Uranium oxide, 96%	lb.	3.25	—	3.60
Vanadium pentoxide, 99%	lb.	10.50	—	.....
Pyrites, foreign	unit	.17	—	.....

Plant Supplies

BUILDING MATERIALS

Common clay bricks	M	14.00	—	15.00
Faced brick	M	37.00	—	46.00
Hollow tile, 4x12x12	M	56.00	—	86.00
Hollow tile, 12x12x12	M	162.00	—	218.00
Lime	ton	17.50	—	.....
Portland cement	bbl.	3.45	—	3.62
Single glass (82-lb.), 10x26-16x24		21.00	—	27.00
Double glass (164 lb.), 10x26-16x29		31.00	—	39.00
Yellow pine lumber	M	39.00	—	45.00
Cypress	M	70.00	—	.....
Tarred felt (14-lb. sq.)	ton	52.00	—	55.00
Roofing pitch	ton	18.00	—	22.00
Asphalt coated roofing (35-55-lb.sq.)	sq.	1.60	—	2.45
Slate surfaced asphalt shingles	sq.	5.25	—	5.50
Corrugated galvanized iron	ton	100.00	—	.....
Putty	100 lb.	6.00	—	.....
Red oxide (Fpte. Copperas)	100 lb.	15.00	—	20.00
Native red oxide	100 lb.	3.25	—	5.00
Red metallic paint	100 lb.	1.20	—	1.50
White lead in oil	100 lb.	13.00	—	.....
White lead (dry)	100 lb.	9.00	—	.....
Red lead in oil	100 lb.	14.50	—	.....
Red lead (dry)	100 lb.	13.00	—	.....
Zinc oxide (dry)	100 lb.	12.00	—	13.00
Zinc oxide—leaded	100 lb.	8.50	—	10.00
Yellow ochre	100 lb.	1.50	—	10.00
Ultra marine blue	100 lb.	14.00	—	50.00
Prussian blue	100 lb.	135.00	—	150.00
Chrome green	100 lb.	35.00	—	60.00
Paris green	100 lb.	37.00	—	.....
Mineral black	100 lb.	1.75	—	2.25
Powdered bone black	100 lb.	5.50	—	12.00
Lamp black	100 lb.	15.00	—	45.00
Gas carbon	100 lb.	16.00	—	25.00
Mexican petroleum pitch	100 lb.	1.00	—	2.00
Gilsonite	100 lb.	2.00	—	2.50
Coal tar pitch	100 lb.	.60	—	1.25

STRUCTURAL IRON

Blue annealed sheet iron	ton	71.00	—	76.00
Black sheet iron	ton	87.00	—	.....
Galvanized iron	ton	101.00	—	.....
Tern plate, 8-lb. coating	ton	141.00	—	.....
Tern plate, 15-lb. coating	ton	175.00	—	.....
Tern plate, 25-lb. coating	ton	200.00	—	.....
Tern plate, 40-lb. coating	ton	230.00	—	.....
Tin plate, prime	ton	140.00	—	.....
Tank plates	ton	53.00	—	57.00
Beams, channels, angles, T's, Z's	ton	49.00	—	54.00
Rivets	ton	84.00	—	.....
Steel pipe, ¾ to 3-inch	ton	51.00	—	.....
Bar iron	ton	62.00	—	.....
Chain (1 inch proof coil)	ton	150.00	—	.....
Nails, bolts, nuts, washers	ton	65.00	—	80.00
Tool steel, special alloys	ton	300.00	—	500.00
Bessemer pig iron	ton	29.35	—	.....
Bessemer steel	ton	38.50	—	.....
No. 2 foundry	ton	32.00	—	.....

POWER HOUSE SUPPLIES

Steam packing, rubber duck	lb.	.99	—	1.10
Asbestos, high pressure	lb.	1.76	—	.....
Asbestos, wired	lb.	1.30	—	.....
Asbestos, graphited braid	lb.	1.21	—	.....
Asbestos, wick	lb.	.75	—	.....
Rubber, sheet	lb.	.66	—	.....
Cup grease	lb.	.07	—	.....
Transmission grease	lb.	.07	—	.....
Axle grease	lb.	.04½	—	.....
Gear grease	lb.	.04½	—	.....
Cotton waste	lb.	.08½	—	.11
Hose, underwriters, 2½ in	ft.	.75	—	.....
Hose, air, ¾ in	ft.	.50	—	.60

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Alabama

DADEVILLE — The Dadeville Naval Stores Co. plans to install a turpentine distillery. J. D. Arnold, Dadeville, interested.

California

FRESNO—The Union Oil Co., Divisadero and Roosevelt Sts., plans to build an addition to its oil distributing plant; also six substations. Estimated cost, $200,000.

LOS ANGELES—The Bonnie-Reed Film Manufacturing Co., Niles, plans to build a motion picture plant, on Sunset Boulevard and Bronson Ave., to include laboratories, power plant, offices, etc. Total estimated cost, $1,000,000. Train & Williams, 225 Exchange Bldg., architect.

PORTERVILLE—The city trustees are having plans prepared by Olmsted & Gillelen, engineers, Hollingsworth Bldg., Los Angeles, for the construction of a gas plant.

RICHMOND—The Standard Oil Co., 200 Bush St., San Francisco, has awarded the contract for the construction of a 3-story laboratory, here, to P. J. Walker & Co., Monadnock Bldg., San Francisco. Estimated cost, $175,000.

VERNON—The Pan-American Petroleum Co., Security Bldg., Los Angeles, will build an oil refinery on a 12-acre site in the industrial district here, for the manufacture of greases and paraffine products. Estimated cost, $250,000. T. D. Boyce, care of company, engineer.

Colorado

EMPIRE—The Empire Gold Mining, Milling & Tunnel Co. plans to build a 50-ton concentrating mill and is in the market for milling plant equipment and lumber. Estimated cost, $50,000. W. A. Snyder, superintendent.

GEORGETOWN—The Georgetown Tunnel & Transportation Co. plans to build a crushing and concentrating mill and is in the market for a crusher, motor concentrating tables, etc. Address C. A. Basse, 608 Dearborn St., Chicago, Ill., secretary.

Connecticut

HARTFORD—The Board of Water Commissioners received bids for the construction of a filtration plant, from the Foundation Co., 233 Broadway, New York City, $627,507; F. T. Ley & Co., 495 Main St., Springfield, Mass., $632,649; H. E. Fox Construction Co., Inc., 81 East 125th St., New York City, $668,955. Noted Feb. 15.

PLAINVILLE—Landers, Frary & Clark, Commercial and Centre Sts., has awarded the contract for the construction of a 4-story, 60 x 100 ft. factory on Woodford Ave., for the manufacture of celluloid, to the Torrington Building Co., 197 Water St., Torrington. Estimated cost, $50,000.

Florida

JACKSONVILLE—The Virginia-Carolina Chemical Co., 11 South 12th St., Richmond, Va., plans to build a modern fertilizer plant on Talleyrand Ave., here. Estimated cost, $200,000.

Illinois

CHICAGO—Armour & Co., Union Stock Yards, has awarded the contract for the construction of a 2-story, 40 x 80 ft. glycerine distilling plant at 1355 West 31st St., to J. L. Carnegie & Sons, 189 West Madison Ave. Estimated cost, $15,000.

CHICAGO—The Peoples Gas, Light & Coke Co., 122 South Michigan Ave., plans to build a gas tank, having a capacity of 50,000,000 cu.ft. of gas per annum, at Crawford Ave. and 36th St. Estimated cost, $15,000,000. R. Schenck, care of owner, engineer.

Indiana

CHESTERTON—The Gary Chemical Co., recently incorporated with $50,000 capital, plans to build a plant for the manufacture of chemicals and medicinal preparations. V. U. Young, Gary, general manager.

EAST CHICAGO—The East Chicago & Indiana Harbor Water Co., 113 Monument Circle, Indianapolis, has awarded the contract for the construction of a new filtration plant, to the Warner Construction Co., 189 West Madison St., Chicago, Ill. Estimated cost, $333,000. Noted Feb. 15.

Kansas

BLUE MOUND—The Commerce Mining & Royalty Co., Miami, Okla., plans to build a sludge mill to handle sand tailings at Webber mine, and is in the market for tables, motor, rolls, elevators and transmission belting. Estimated cost, $10,000. J. Newton, general superintendent.

TREECE—The King Brand Mining Co., Picher, Okla., plans to build a concentrating plant here. Estimated cost, $100,000. W. Landrum, superintendent.

TREECE—The Wachusetts Mining Co., Commerce, Okla., plans to build a mill here. A. Mayerhoff, superintendent.

Maryland

HAGERSTOWN—The Maryland Smelting & Refining Co., West Church St., has awarded the contract for installing a brass-smelting furnace, having 1 ton capacity, a complete metal concentrating plant and metallurgical laboratory, to the Universal Engineering Corp., 1229 Calvert St., Baltimore.

SOLLERS STATION (Sollers P. O.)—The Aluminum Ore Products Co., Inc., 800 Maryland Trust Bldg., Baltimore, plans to enlarge its plant here. Estimated cost, $8,000,000. J. E. Aldred, chairman of the board of directors of the Consolidated Gas, Electric Light & Power Co., Lexington Bldg., Baltimore, interested.

Massachusetts

CHATHAM—The Bureau of Yards and Docks, Navy Department, Washington, D. C., plans to build a septic tank and sewage disposal plant here. Estimated cost, $75,000.

NEW BEDFORD—W. A. Robinson & Co., 144 South Water St., plans to rebuild its plant for the manufacture of oil, recently destroyed by fire, entailing a loss of $75,000.

WORCESTER—The Morgan Spring Co., West Boylston St., plans to build a 1-story, 41 x 80 ft. addition to its main plant to be used as a rolling mill.

Michigan

DETROIT—J. G. Kastler & Co., architects, 523 Chamber of Commerce Bldg., will soon award the contract for the construction of a 2-story, 120 x 150 ft. brass foundry, for Lokomsky Bros., Dubois St. and East Grand Boulevard.

Missouri

PLATTSBURG—The city plans an election soon to vote on a $70,000 bond issue for a new waterworks system. Plans include the construction of a dam and filtration plant, etc.

WACO—The Tulsa-Pittsburg Mining Co., Pittsburg, Kan., plans to move its mill from Diamond and erect same at Waco, and is in the market for boilers, hoist, pumps, rock drills and tables. Estimated cost, $75,000. A. O'Connor, superintendent.

WEBB CITY—Wommack & Co. plans to build a concentrating plant. Estimated cost, $60,000. E. Wommack, superintendent.

Montana

HELENA—The State Legislature has appropriated $50,000 for the construction of a laboratory here for the State Board of Health.

Nebraska

OMAHA—The Skinner Packing Co., 904 First National Bank Bldg., has awarded the contract for the construction of a 6-story, 65 x 65 ft. fertilizer factory, to Collins Bros., Omaha. Estimated cost, $50,000.

OMAHA—The State Legislature, Lincoln, plans to appropriate $40,000 for installing electrical apparatus, laboratory equipment, etc., in the University of Nebraska, College of Medicine, at 42nd St. and Dewey Ave. J. Latenser, 632 Bee Building, architect.

New Jersey

HARRISON—Berkowitz Bros. are having plans prepared by M. J. Nadel, architect, 15 Clinton St., Newark, for the construction of a candle factory on Plane St. Estimated cost, $50,000.

NEWARK—The Miller & Moran Chemical Works, Meadow St. near Lincoln Highway, plans to rebuild its plant, recently destroyed by fire, entailing a loss of $25,000.

New York

BROOKLYN—J. Bene & Sons, 641 Dean St., has had revised plans prepared by M. Freehof, architect, 405 Lexington Ave., New York City, for a 1-story, 100 x 100 ft. chemical factory on Clinton Ave. near Fulton St. Estimated cost, $35,000. Noted Dec. 30.

BROOKLYN—The Beth Moses Hospital, Hart St. and Stuyvesant Ave., will install a laboratory in the 5-story, 90 x 100 ft. addition to the hospital which it plans to build. Total estimated cost, $350,000. H. J. Nurick, 957 Broadway, architect.

CANASTOTA—The city plans election soon to vote on proposition to install sterilization plant.

MIDDLEPORT—The Board of Trustees plans to install a filtration plant and equipment, using the water from the Barge Canal. Estimated cost, $20,000.

OLEAN—J. J. Mahoney, supervisor of health of Cattaraugus and Chautauqua Counties, has petitioned the State Board of Health, Albany, for the construction of a pathological laboratory here.

OLEAN—The United States Glue Co. plans to build a 1-story and 2-story glue manufacturing plant. Estimated cost, $300,000.

UTICA—E. Kemper, city engineer, has completed plans for the construction of a sewage disposal plant to be located in the Sixteenth Ward.

UTICA—The State Hospital Commission, Capitol, Albany, has awarded the contract for the construction of a 2-story, 44 x 60 ft. laboratory and mortuary at the State Hospital, here, to Laporte & Goodman, P. O. Box 284, Albany, $23,900. Noted Feb. 15.

WATERTOWN—The city is having surveys made and plans prepared by E. W. Sayles, city engineer, for the construction of a sewage disposal plant in the Eighth Ward.

WATERTOWN—The Water Board plans to equip a purification and pumping station with apparatus for making water analysis and alum tests. J. W. Phippen, superintendent.

WILLARD—The New York State Hospital Commission, Capitol, Albany, will receive bids until April 9 for the construction of a chlorinating plant at the Willard State Hospital here. F. L. Warne, steward, L. F. Pilcher, state architect. Noted March 15.

Ohio

FINDLAY—The State Board of Health, Columbus, has ordered the city to build a sewage treatment plant. U. K. Stringfellow, city engineer.

FREMONT—The city plans to build a filtration plant. Estimated cost, $90,000. G. W. Lesher, city engineer.

NORWALK—The State Board of Health has ordered the city to build a sewage disposal plant. C. W. Anderson, mayor.

PAULDING—The city plans to purchase chemical equipment for the local fire department.

TOLEDO—F. S. Royster Guano Co., 813 Second National Bank Bldg., plans to build a sulphuric acid plant on a 5-acre site adjoining its fertilizer factor on Stickney Ave. Estimated cost, $500,000.

TOLEDO—The Standard Oil Co. of Ohio, Gas Bldg., Cleveland, has purchased a site of 810 acres northeast of the city and is having plans prepared for the construction of twenty-four crude oil stills, twelve running stills, eighty pressure stills, and from twelve to twenty-four other stills, steel storage tanks, warehouses, etc. Estimated cost, between $4,000,000 and $5,000,000.

WAUSEON—The city plans an election about May 1 to vote on a $170,000 bond issue for the construction of a filtration plant, pipe lines and an 80,000,000-gal. capacity impounding reservoir. W. J. Sherman, 613 Nasby Bldg., Toledo, engineer.

Oklahoma

BURKBURNETT—The Interstate Refining Co., recently organized, plans to build an oil refinery here, having a capacity of 1500 bbl. J. A. Jones, president.

PICHER—The Beck Mining Co. plans to move its mill from Quapaw field and erect same at Picher, and is in the market for hoists, rock drills, tubs and ground cars. Estimated cost, $75,000. A. Beck, general manager.

Oregon

GASCO—The Portland Gas & Coke Co., Gasco Building, Portland, has awarded the contract for the construction of an extension to its gas plant here, to O. R. Wayman, 939 Thurman St., Portland. Estimated cost, $15,000.

PORTLAND — The Pfister & Vogel Leather Co., 443 Virginia St., plans to build a 7-story, 100 x 125 ft. addition to its tannery. Estimated cost, $125,000. C. P. Bossert, engineer, care of company, is receiving bids.

Texas

BIRDVILLE—The Ok-In Producing & Refining Co. plans to build an oil refinery here, having a daily capacity of 5000 bbl. Estimated cost, $250,000. G. W. Merrill, Ft. Worth, president.

BURKBURNETT—The Meridian Gasoline Co. plans to build a casinghead gasoline plant. W. K. Campbell, president.

EL PASO—The El Paso County Medical Society plans to build a 6-story office building at Mesa Ave. and Franklin St. Plans include the installation of community laboratories, operating rooms, etc.

FT. WORTH—The Eldorado Refining Co., Eldorado, Kan., plans to build an oil refinery here, having a daily capacity of 5000 barrels.

FT. WORTH—The Home Oil & Refining Co., recently incorporated with $5,000,000 capital, has awarded the contract for the construction of a refinery, to W. C. Hedrick Construction Co., Ft. Worth National Bank Bldg. W. M. Babcock, 1119 North Main St., Tulsa, Okla., president.

FT. WORTH—The Texas Producing & Refining Co., recently incorporated with $2,000,000 capital, plans to build an oil refinery. W. H. Newberry, Childress, and J. Gee, Ft. Worth, interested.

HOUSTON—The Humble Oil & Refining Co., 1019 Main St., plans to build a 10,000-bbl. lubricating oil plant on the ship channel near here. Estimated cost, $2,000,000.

WICHITA FALLS—The New-Tex Refining Co. plans to build an oil refinery, having a capacity of 2000 bbl. E. B. Bailey, president.

Utah

SALT LAKE—The General Reduction & Chemical Co., 23 West 2nd St., plans to build a plant for the manufacture of sulphuric, nitric, hydrochloric and other acids. Estimated cost, $250,000.

Wisconsin

BUTTE DES MORTS—The Peerless Paper Products Co., Menasha, has purchased a site on Little Lake, near here, and plans to build a new pump and paper mill. Estimated cost, $100,000. T. E. McGillan, general manager.

GREEN BAY—The Ft. Howard Paper Mill, recently organized, plans to build a paper mill. Estimated cost, $200,000. A. Cafvin, manager.

MENASHA—The Peerless Paper Products Co., Manitowoc St., is having plans prepared by L. A. De Guere, engineer, Wood County Bank Bldg., Grand Rapids, for the construction of a 3-story, 40 x 150 ft. paper mill.

SHEBOYGAN—The American Hide Co., 1102 Wisconsin Ave., has awarded the contract for the construction of a 4-story tannery on South Water and Wisconsin Ave., to Morris Shukdart. Estimated cost, $8750.

SHEBOYGAN—Juul & Smith, architects, 805 North 8th St., will receive bids until April 15, for the construction of a 4-story, 100 x 250 ft. tannery on Illinois and Water St., for the Badger State Tannery Co. Estimated cost, $45,000.

Ontario

GUELPH—James, Loudon & Hertzberg, engineers, Excelsior Life Bldg., Toronto, will receive bids in about five weeks for the construction of a 4-story, 80 x 200 ft. factory on Metcalf St., for the Premier Rubber Co. Estimated cost, $135,000.

KITCHENER—The Kaufman Rubber Co., 419 King St., plans to build an addition to its plant. Estimated cost, $40,000. A. R. Kaufman, manager.

OTTAWA—The Y. M. C. A., Metcalfe St., plans to build a mechanical filtration plant to filter 30,000 gal. of water for a swimming tank. G. Crain, president.

ROCKLAND—W. C. Edwards & Co., Ltd., Sussex St., Ottawa, will soon receive bids for the construction of a pulp and paper mill here. Estimated cost, $3,600,000.

Quebec

THREE RIVERS — The International Paper Co., 30 Broad St., New York City, N. Y., plans to build a 1- and 2-story paper plant here. Estimated cost, $3,000,000.

Saskatchewan

REGINA—The Continental Oil Co. plans to build an oil refinery here. Estimated cost, $1,000,000. A. B. Allen, local manager.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold a meeting at 29 S. LaSalle St., Chicago, May 13 and 14.

THE AMERICAN CHEMICAL SOCIETY will hold a meeting in Buffalo, April 7 to 11.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its annual meeting in New York City from April 3 to 5.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its 22nd annual meeting at Atlantic City, N. J., June 24-27. The headquarters will be at the Hotel Traymore.

THE AMERICAN ZINC INSTITUTE will hold its annual meeting at St. Louis, Mo., May 12.

THE NATIONAL FOREIGN TRADE COUNCIL will hold its sixth National Foreign Trade Council at the Congress Hotel, Chicago, Ill., on Thursday, Friday and Saturday, April 24, 25 and 26, 1919.

THE NATIONAL SERVICE COMMITTEE of the Engineering Council will hold a meeting at Chicago, Ill., April 23 to 25.

THE NEW JERSEY CHEMICAL SOCIETY will hold a meeting in Newark on April 7.

Industrial Notes

THE COMMONWEALTH SILICA CO., Ottawa, Ill., producer of sand for iron and steel manufacturing purposes, has recently purchased the property of the Ottawa Steel Molding Sand Co., which has 84 acres of "Buffalo Rock" land and all equipments.

THE COE-STAPLEY MFG. CO., formerly at 135 Broadway, New York, is now located at 136 Liberty Street.

THE TOLLAND MFG. CO., Montreal, Can., has recently placed on the market a metal known as "Tamco," which is particularly adapted for rolling mill and all other bearings subject to heavy pressure.

THE OHIO METAL BRIQUETTING CO., Cleveland, Ohio, has placed a contract with the Crowell-Lundoff-Little Co. for a new plant for manufacturing briquets of scrap metal. Annealing furnaces and some other equipment will be required.

THE COMMERCIAL AND INDUSTRIAL BUREAU OF THE POLISH NATIONAL DEPARTMENT has been organized for the purpose of re-establishing commercial relations between the United States and Poland. It will collect all data and information to form a basis for the work of the future official Polish agencies in this country. The Bureau will be glad to furnish information concerning trade conditions and business opportunities in Poland and will also direct individuals and organizations desirous of getting in contact with the Polish market. The Bureau is established at 1032 Aeolian Building, 33 West 42nd St., New York City.

THE NATIONAL ANILINE & CHEMICAL CO., INC., New York, N. Y., announces a new product of its factories in Niagara Blue B R. It is identical with Diamine Blue B X and Benzo Blue B X, which were formerly imported. These prototypes were some of the most widely used brands of Direct Blue, and were put to many special uses.

THE WRIGHT CHEMICAL CORPORATION is enlarging its plant for the manufacture of dyes, intermediates and other chemicals, among which are sulphur colors, dinitrophenol, dinitrochlorbenzol, indophenol, para amidophenol base, para amidophenol and hydrochloride. Mr. A. A. Matheson, who recently resigned as general manager of the Union Dye & Chemical Corp., Kingsport, Tenn., has been elected president of the Wright concern, succeeding Mr. E. J. Wright, who is now vice-president. Mr. A. E. Crocker continues as treasurer. The plant of the Wright Chemical Corp. is at Springfield, N. J., and the office at 38 Park Row, N. Y. C.

TATE-JONES & CO., INC., furnace engineers, Pittsburgh, Pa., announced that after Feb. 1, 1919, Mr. Edward S. Davis will act as district manager, directing sales and service in the Chicago district, with offices located at 931 Monadnock Bldg., Chicago, Ill. Mr. Davis has returned to the company after six months of service as chief, Fuel Oil Section, Bureau of Oil Conservation, United States Fuel Administration.

SCHAEFFER & BUDENBERG, Brooklyn, N. Y., announce the establishment of a selling office at Tulsa, Okla. Mr. T. C. Eales has been appointed as district manager.

FREYN BRASSERT & CO., engineers, Peoples Gas Bldg., Chicago, Ill., announce the appointment of Mr. Wyman Eaton as chief engineer, taking effect Feb. 15, 1919. Mr. Eaton recently resigned as engineer in charge of rolling mill work of the Mesta Machine Co. to take up his new duties.

WALLACE & TIERNAN CO., INC., 349 Broadway, New York City, manufacturers of W & T chlorinating apparatus, have recently appointed Mr. David Morey, Jr., Southwestern representative. Mr. Morey is located at 507 Scollard Bldg., Dallas, Texas.

WARREN WEBSTER & CO., Camden, N. J., announce the opening of a Texas office at 805 Sumpter Bldg., Dallas, Texas, with Mr. W. B. Irwin in charge as district representative.

EPPING-CARPENTER PUMP CO., Pittsburgh, Pa., announce that Mr. Theodore R. Hermansen, formerly of the Harrison Works of the Worthington Pump & Machinery Corp., has become associated with them as works manager.

WESTINGHOUSE CHURCH KERR & CO., INC., announce the opening of an office in the Western Indemnity Bldg., Dallas, Texas, in charge of Mr. A. W. Nichols.

THE NEW JERSEY ZINC CO., New York, had Mr. C. A. Stedman invite a score of the business press representatives to look over its building at 160 Fulton St. Excellent views of their operations were illustrated by motion pictures, after which the applications of zinc were shown. Hinges, doorknobs, doors, electric lamps, wastebaskets, desk sets, ornamental castings and innumerable articles of practical use were shown. All agreed that zinc takes a more beautiful metal finish than brass or bronze. No doubt manufacturers expecting to establish Asiatic trade will do well to promote zinc ware there, as those who like the silvery moon finish will be delighted with zinc products.

THE ELYRIA ENAMELED PRODUCTS CO., Elyria, Ohio, has recently added to its technical force Mr. William H. Jackson, who will serve as engineering assistant to the plant superintendent, and Mr. Max Donauer, who will co-operate with the sales and chemical departments in the application of glass enameled equipment to the chemical industry.

ARTHUR D. LITTLE, INC., Cambridge, Mass., announces that Mr. Herbert L. Sherman, formerly president of the New England Bureau of Tests, Inc., and more recently in charge of inspection for the Construction Division of the United States Army, has joined the corporation, and will be in charge of the department for the testing and inspection of structural materials.

SILL & SILL, 1011 Figueroa St., Los Angeles, Calif., are equipping new offices at the foregoing address and installing complete laboratory equipment for ore testing.

THE CHICAGO PNEUMATIC TOOL CO., Chicago, Ill., has opened offices and warehouses at Tulsa, Okla. and El Dorado, Kansas. The Boston office has recently been removed to 182 High St., in charge of Mr. F. S. Eggleston, district manager of sales. The Detroit office has been moved from 236 Hancock Ave. to 502 Farwell Bldg. The following changes in the staff are announced: Mr. J. I. Edwards has been appointed as manager rock drill sales division, succeeding Mr. E. Eklund, who has been appointed special foreign representative. Mr. Fred H. Waldron, formerly Minneapolis representative, has been appointed

manager pneumatic tool sales division, succeeding Mr. J. G. Osgood, resigned. Mr. Nelson E. Gatch has been made district manager of sales at Minneapolis, with offices at 301 Metropolitan Bank Bldg. Mr. J. K. Haigh has been made assistant district manager of sales in the San Francisco office at 175 First Street.

PAUL O. ABBE, INC., is the title of the new organization created to succeed the business of Paul O. Abbe. The new corporation has purchased a site on which new buildings are being erected to afford increased manufacturing facilities. Mr. Henry Selman, one of the original inventors and developers of the grinding mill, is associated with the new corporation.

THE ELECTRIC FURNACE CONSTRUCTION Co.'s president, Mr. Frank Hodson, returned from Europe Feb. 24, accompanied by Mr. Mr. Harry Etchells, one of the inventors of the "Greaves-Etchells" furnace. Mr. Etchells, during his short stay in America, is to act in an advisory capacity on the latest European practice.

THE AMERICAN STEAM CONVEYOR CORP., Chicago, Ill., announces the appointment of Mr. C. E. Hague as sales manager. Mr. Hague was formerly production engineer of the Mid-West Engine Co., Indianapolis, Ind.

MURPHY & BREWSTER, 40 Cedar St., New York City, announce that Mr. John D. Lyman, formerly sales manager of the Edison International Corp., has been associated with them since March 1, 1919.

THE ELECTRIC FURNACE Co., Alliance, Ohio, has under construction ten Baily electric brass furnaces at the Salem plant to fill a Mexican contract and other similar domestic and foreign orders. This company has just closed a contract to ship to Mexico complete Baily electric furnace equipment for melting brass. The furnaces are of the tilting type, and are rated at 105 kw. electrical capacity, 1500 lb. hearth capacity and a melting rate of 600 lb. per hour.

THE PULVERIZED FUEL EQUIPMENT CORP. has recently been organized for the purpose of taking over the business of the Locomotive Pulverized Fuel Co., and to broaden the activities of the latter to cover the central power station, metallurgical and industrial fields. The head offices are at 30 Church Street, New York City, with a Canadian office in the Transportation Bldg., Montreal. The officers of the Pulverized Fuel Equipment Corp. will be J. S. Coffin, chairman; J. E. Muhlfeld, president; H. F. Ball, vice-president executive, H. D. Savage, vice-president in charge of sales; V. Z. Caracristi, vice-president in charge of engineering, and Samuel G. Allen, secretary-treasurer.

THE ELECTRICAL STEEL Co. OF INDIANA, Indianapolis, Ind., recently completed the addition to its foundry immediately adjacent to the Heroult electric furnace to house a chemical laboratory. The addition consists of a detached I-story building, and is fully equipped with complete chemical apparatus for the analysis of melting stocks and alloys and for the determination of preliminary and final tests of the product of high-grade electric steel castings. In addition to providing for accurate chemical control arrangements have been made for photographic work.

Manufacturers' Catalogs

W. S. ROCKWELL Co., 50 Church Street, New York, calls attention to Bull. No. 39 on rotary annealing and heat-treating furnaces. The design of the furnace is that of a rotating horizontal cylinder with a refractory or metallic spiral lining, so that when material is charged in bulk into the charging drum at one end it is gradually and automatically conveyed through numerous convolutions and at gradually increasing temperature to the other end, where it is automatically discharged at the exact time that it reaches its required temperature. A concentric hood serves to automatically close the discharge opening except at the lowest point of revolution and time of discharge. The hood also serves to guide the material as it leaves the furnace. The furnace is intended to handle, either for annealing, hardening, tempering, blueing or other heat treatment, any small pieces of like dimensions in either brass, copper, steel or other metals, such as cartridge shells, eyelets, ferrules, buttons, caps, cups, coin blanks, steel balls, saw teeth, tacks, screws, rivets, rings, springs, nuts, punchings, etc.; in fact, any small pieces which will travel freely and pass through the openings without choking them. A table on page 13 shows that the fuel consumption in this rotary furnace is very low indeed, averaging about 250 pounds of heat-treated material to a gallon of oil. The labor cost is also low. A novel heat-treatment chart is shown on page 15. Copies will gladly be sent upon request.

THE DENVER FIRE CLAY Co., Denver, Colo., has issued a pamphlet on its technical service relating to furnaces, refractories, laboratory equipment and chemicals. Bulletin 325, on "China Kilns," is another booklet which has just been issued by this company.

SCHAEFFER & BUDENBERG, Brooklyn, N. Y., illustrates and describes its Columbia recording thermometers in Catalog No. 300, just off the press. This attractive catalog is well illustrated, showing actual installations.

THE BLAW-KNOX Co., Pittsburgh, Pa., calls attention to folders, entitled "Build Your Road With Blawforms," "Blawforms for Road, Sidewalk, Curb, and Curb and Gutter Construction," and also a booklet entitled "Products of the Blaw-Knox Co."

THE JEFFREY MANUFACTURING Co., Columbus, Ohio, has issued a descriptive Catalog, No. 210, on the Jeffrey pivoted bucket carrier, for handling coal, ashes, clinker, etc. The catalog is divided equally in its 96 pages between convincing and keenly illustrated details of the carrier, many interesting exterior and interior pages of large power plant equipments and also reproductions of dimensioned blue prints in actual color of typical views for the various sizes of carrier equipment which should be of interest to the architect and engineer. This company has also gotten out Catalog No. 245, on the Jeffrey type-A shredder, which illustrates and describes in 24 pages its swing hammer shredder. Copies will gladly be sent upon request.

THE STEERE ENGINEERING Co., Detroit, Mich., has issued Bull. No. 37, on gas purification, covering the removal of carbonic acid, hydrogen-sulphide, carbon disulphide, ammonia and cyanamide. The bulletin describes methods of purification with lime and iron oxide.

THE SWENSON EVAPORATOR Co., Chicago, Ill., has prepared a pamphlet on the making of maltose, malt syrups and malt extract with special reference to the conversion of breweries to the manufacture of these materials. The pamphlet describes Swenson equipment suitable for this purpose.

THE DURIRON CASTINGS Co., New York, N. Y., has just published Bull. 103, describing Duriron denitrating towers. The pamphlet consists not only of a description of the denitrating and oxidizing system manufactured by the company, but also a brief treatise on the general principles of denitrating spent acid from nitration processes.

THE NICU STEEL CORP., LTD., Box 128, Welland, Ont., Canada, has received from the press its booklet entitled "Nicu Steel," which is a high-grade alloyed steel able to stand hard usage and rough treatment, viz.: Transmission shafts and gears, crank shafts, axles, springs, valve stems, rods, etc. This company has a New York office at 43 Exchange Place.

THE QUIGLEY FURNACE SPECIALTIES Co., INC., New York City, illustrates and describes in Bull. No. 11 the Quigley powdered fuel system for preparing, distributing and burning powdered fuel.

THE J. D. FATE Co., Plymouth, Ohio, has just issued two bulletins on gasoline locomotives. These bulletins show the locomotive in use in various companies.

THE WALTER A. ZELNICKER SUPPLY Co., St. Louis, Mo., announces that its Bull. No. 260, on steel sheet piling, is ready for distribution.

THE AIR REDUCTION Co., INC., 120 Broadway, N. Y., has issued folders which show the benefits derived from the use of Airco products and methods, both for the purpose of building up worn frogs and repairing damaged locomotive cylinders.

ADAM HILGER, LTD., 75A Camden Road, London, N. W. 1, England, calls attention to an attractive booklet on Abbe refractometer with water jacketed prisms, and also a booklet on the Hilger wavelength spectrometer (constant deviation type) and the Nutting photometer.

THE SCIENTIFIC MATERIALS Co., Pittsburgh, Pa., recently issued a pamphlet on American Medical museum jars, which it designed and patented.

THE DEISTER CONCENTRATOR Co., Fort Wayne, Ind., has issued a special bulletin dealing with the No. 7 diagonal deck coal washing table.

THE HENDRICK MANUFACTURING Co., Carbondale, Penn., has just received from the press an attractive 128-page catalog entitled "Perforated Metals." It illustrates the various designs of screen plates, manufactured screens, elevator buckets, conveyor trough and flights, and general sheet and light structural work.

THE LAWRENCE PUMP & ENGINE Co., Lawrence, Mass.: Catalog "C" illustrates and describes centrifugal pumps.

THE GRISCON-RUSSELL Co., 90 West St., New York, calls attention to Bull. 609, on Reilly multiscreen feed water filter and grease extractor.

THE LEEDS & NORTHRUP Co., Philadelphia, Pa., has just issued a new bulletin entitled "Checking Thermocouple Pyrometers." It discusses the importance of maintaining standards and of checking in pyrometry. It points out sources of error and the remedies for troubles in theremocouples, millivoltmeters, cold junctions and potentiometers. It outlines a commercial checking laboratory, including a special checking furnace, precision potentiometers and standardized thermocouples.

Stocks and Bonds

Closing Bid and Asked Quotations February 27, on N. Y. Stock Exchange

CHEMICAL COMPANIES

	Bid	Ask		Bid	Ask
Am.Ag.Ch....	103½	103¾	Mat.Al.Wk...	131	44
do.pf.....	99	100	Ten. C. & C..	2½	13
Barrett Co...	120½	121	Un. Dyewood.	55	61
do.pf	113½	117½	do. pf.....	90	95
Gen.Chem....	170	180	Va.-Car. Ch..	56½	57
do.pf.....	102	104	do. pf.....	111	114
Int.Ag.Ch....	16	18			
do. pf.....	65	66			

Bonds

Am. Ag. Ch., 1st cv. 5s, '28	97½	99¾
Am. Ag. Ch., cv. db. 5s, '24	104	105½
Int. Ag. Ch., 1 mtg. & col. tr. 5s, '32	81½	81¾
Va.-Car. Ch., 1 mtg. 5s, '23	95¾	96
Va.-Car. Ch., cv. db. 6s, '24	101	101¾

PETROLEUM COMPANIES

	Bid	Ask		Bid	Ask
Asso. Oil Co..	72½	73½	P-A Pet & Tr.	78¾	79¾
Cal. Pet.....	25¾	26¼	do. pf.....	134	139
do.pf.....	68¾	69¾	Pierce Oil ..	18¾	18¾
Col. G. & E..	44½	45	Royal Dutch..	92½	93
Mex. Pet.....	180¾	181	Sinclair O & R	45¾	46
do. pf.....	105	109	Texas Co.....	208½	209
Ohio Cit. Gas.	38¾	38¾	Tex. Pac. Ld.		
do. pf.....			Tr.....	260	300
Ohio Fuel S...	45¾	46¼	Tidewater Oil.	210	220
Okla. P. & R..	8¼	8½			

Bonds

Columbia Gas & Electric, 15s, '27	84¾	85
Col. G. & El., std. 1 5s, '27	84¾	....
Pan-Am. Pet. & Tr. 1 6s, '19-'27	125	....
Pierce Oil, cv. db. 6s, '24	94¾	94¾
Pierce Oil, cv. 5% Notes, '20	102	103¾
Sin. O. & R. 1 In. 7s, '20, with stk. war...	103¾	103¾
Sin. O. & R. 1 In. 7s, '20 without stk. war..	96¾	96¾
Texas Co., db. 6s, '31	102¾	103
Union Oil of Cal. 1 5s, '31	93	94
United Fuel Gas 1 mtg. 6s, ser.A, '36....	96	97

IRON AND STEEL SECURITIES

	Bid	Ask		Bid	Ask
Am. St. F....	81	82	Pitts.Ste. pf...	91	95
Beth. Steel...	65	66	Rep. Iron &		
do. class B.	65½	66	Steel.....	81	81¾
do. pf., 8%.	104½	105	do. pf.....	101½	103½
do. pf., 7%.	91½	99	Sloss Sheff. I.		
Central Fdry.	13	21	& S.....	52	53
do. pf.....	30½	34	do. pf.....	84	90
Col. F. & I...	41½	42	Superior Steel.	36½	37
do. pf.....	105	115	do. 1 pf.....	96	98
Cruc. Steel...	65½	65¾	Trans. & W.		
do. pf.....	93¾	100	Steel	40¾	41¼
Great No. Ore	40¾	41	Un. Alloy St..	42½	43
Gulf Sta. Steel	53	54	U.S.C.I.P.&F.	19	19½
do. 1 pf....	92	98	do. pf.....	54	54¾
Lack. Steel...	69	69½	U. S. Steel....	97¾	97¾
Nlid.St.& Ord.	45½	45¾	Wheeling	114½	115
Nova Scotia			Va. Coal,I&C.	56	59
Steel.....	48¾	50½			

Bonds

Beth. Steel, 1 ext. gtd. S.F. 5s, '26	96	96½
Beth. Steel, 1 In. ref. 5s, Ser. A, '42	88	88½
Beth. Steel, P. M. & I. S. F. 5s, '36	83½	84½
Buff. & Susq. Iron, 1 S. F. 5s, '32	91	96
Buff. & Susq. Iron, deb. 5s, '27	....	....
Cent. Found. 1 mtg. S. F. 6s, '21	78	82
Col. F. & I., gn. S. F. 5s, '43	90	92
Ill. Steel, db. 4½s, '40	83½	85½
Ind. Steel, 1 mtg. gtd. 5s, '52	96	96½
Lack. Steel, 1 5s, '23	97	98
Lack. Ste., 1 con. mtg. cv. 5s, Ser. A, '50	89	90½
Mid. St. & Ord., clt. cv. S. F. 5s, '36	88	88½
Nat. Tube, 1 mtg. gtd. 5s, '52	94	95
Rep. I. & S., S. F. mtg. 5s, '40	95	95½
Tenn. C. & I. R.R., gn. 5s, '51	92	93
U. S. Steel, S. F. 5s, '63	100	100½
Va. C., I. & C., 15s, '49	85½	86

Published SEMI-MONTHLY *on the* FIRST *and* FIFTEENTH *of each month*

CHEMICAL & METALLURGICAL ENGINEERING

A consolidation of ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

McGRAW-HILL COMPANY, INC.
Tenth Avenue at 36th Street
NEW YORK

JAMES H. McGRAW, President
ARTHUR J. BALDWIN, Vice President E. J. MEHREN, Vice President
J. MALCOLM MUIR, Vice President EDWARD CALDWELL, Treasurer
JAMES H. McGRAW, JR., Secretary

TELEPHONE, 2840 Greeley CABLE ADDRESS, Machinist, New York

WASHINGTON, Colorado Bldg. SALT LAKE CITY, Newhouse Bldg.
CHICAGO, Old Colony Bldg. PHILADELPHIA, Real Estate Trust Bldg.
SAN FRANCISCO, Rialto Bldg. CLEVELAND, Leader-News Bldg.
LONDON, 6 Bouverie St., E. C. 4.

H. C. PARMELEE, Editor
ELLWOOD HENDRICK, Consulting Editor
ERNEST E. THUM, Western Editor
WALLACE SAVAGE, Assistant Editor

Yearly Subscription price for United States, Mexico and United States dependencies, $3; all other countries, $4. Single Copy, 25c.
When change of address is ordered, the NEW and the OLD addresses must be given. Notice must be received at least 10 days before change takes place. No back copies for more than three months.

Copyright, McGraw-Hill Co., Inc., 1919. Entered as second-class matter July 13, 1918, at the Post Office at New York, N. Y., under the Act of Congress of March 3, 1879.

Circulation of this issue 13,000 *copies*

CONTENTS *for April* 15, 1919

Volume, XX, *Number* 8

EDITORIAL

The Passing of a Friend ... 369
Wanted: A Guardian for the United States ... 369
Railroads and Industrial Research ... 370
Chemical Industry and the Victory Loan ... 370
The Philosophy of Buying at Present High Prices ... 370
Chemistry, Metallurgy and the High Cost of Living ... 371
A Resolution of Forces ... 371

READERS' VIEWS AND COMMENTS

The Bradford Process of Preferential Flotation. By *Reginald S. Dean* ... 372
Recovery of Potash. By *J. S. Grasty* ... 373
Heat-Treating of Shells. By *W. J. Merten* ... 374
Large vs. Small Electric Furnaces. By *R. E. Baker* ... 374
Western Chemical and Metallurgical Field ... 375
Surplus Government Supplies ... 375
Proposed Pan-American Commercial Conference ... 375
Joseph Esrey Johnson, Jr.—An Appreciation. By *Bradley Stoughton* ... 376
The Engineer as a Citizen ... 377
New York Meeting of the American Electrochemical Society ... 380
Buffalo Meeting of the American Chemical Society ... 390
Sewing Chemical Apparatus Made ... 395
American Welding Society ... 400
National Research Fellowships in Physics and Chemistry ... 400
Imports and Exports ... 400
Effecting and Controlling Crystallization of Ammonium Nitrate. By *J. Esten Bolling* ... 401
Erection of Huge Sulphuric, Nitric, Mixed Acid and Denitrating Plant Under War Pressure. By *H. E.* and *C. E. Hollister* ... 406
Electrochemistry in Its Human Relations. By *F. J. Tone* ... 413
Salvaging Industrial Casualties. By *Douglas C. McMurtrie* ... 416
Effect of Certain Accelerators Upon the Properties of Vulcanized Rubber. By *G. D. Kratz* and *A. H. Flower* ... 417
Decomposition of Metals—II. By *Col. A. I. Krynitsky* ... 421
Bituminous Roofing Materials and Construction—I. By *George Landis Wilson* ... 425
Burning Lime in a Gas-Fired Continuous Kiln. By *W. D. Mount* ... 428
Recent Chemical and Metallurgical Patents ... 431
Synopsis of Recent Chemical and Metallurgical Literature ... 433
Micrometer With Pressure Attachment ... 434
Gas Reversing Valve ... 435
New Type of Portable Arc Welder ... 436
Pyrometer for Brass and Bronze ... 436
Trackless Trailer With Dump Car Body ... 437
Book Reviews ... 438
Personal ... 440
Obituary ... 441
Current Market Reports ... 441
Industrial News, Coming Meetings and Events, Stocks and Bonds, Industrial Notes and Manufacturers' Catalogs ... 446

The Passing Of a Friend

IN THE passing of J. E. JOHNSON, JR., we sustain a personal as well as a professional loss. For him we could have wished a more peaceful transition instead of the sudden and accidental death which resulted from being struck by an automobile. For him also we should have desired most earnestly a longer life, well rounded in experience and rich in the honors which inevitably would have come later to one who earned them by sheer merit in his earlier years. The morning and noontide of his life were inspiring, filled with the joy of achievement; that there should have been no afternoon and twilight years, with a peaceful setting of the sun, fills one with pity and regret.

In personality MR. JOHNSON was a virile, dynamic force. Always incisive and direct, he had opinions, expressed them forcibly, and left no doubt as to where he stood. Professionally he made an impression which will be felt and recognized more and more as the years go by. Readers of this journal will recall his serial contributions on the iron blast-furnace and the smelting of iron, which later appeared in book form. To his ability there is ample testimony in the mouths of leaders in the profession, from one of whom, MR. BRADLEY STOUGHTON, we are glad to receive and publish elsewhere in this issue a sincere appreciation.

Wanted: A Guardian For the United States

WRITING in the March *Atlantic* under the title "Developing the Estate," MR. ARTHUR D. LITTLE portrays the American people and their country in terms of an old homestead, heavily mortgaged but rich in resources that need intelligent and conservative development. The picture is alluring as we contemplate the "aggregation of undeveloped empires" which constitute our United States, but also appalling when we are reminded of the "long riot of waste and destruction" that has characterized the handling of our estate. The article makes wholesome reading, and it should be widely circulated for the influence it will have in creating a public conscience on a subject too little understood.

As we see it, the duty of creating this conscience devolves squarely upon scientists and technologists. As long as the people see in a lump of coal only a piece of dirty fuel, so long will they handle it wastefully and refrain from protesting against extravagant and uneconomical use. But let them visualize the vast chemical cosmos that exists in that same lump of dirty fuel —the potential heat, light, power, dyes, explosives, medicines and what not—and then realize that our supplies are not limitless, and we will have a moral force that will not tolerate prodigal waste. But who shall

give the people this new vision if not the men of science to whom the facts are known? Similarly we need to be aroused to a lively sense of our timber waste, our low agricultural yields, our undeveloped water power and the importance of all these things to each of us. Really, the problem of reconstruction, of which we have had so much aimless and fruitless talk, becomes a question of intelligent development of our estate.

MR. LITTLE leaves one with the impression that UNCLE SAM needs a guardian in the form of an economic commission to administer the estate and see that the people get the most out of it. The suggestion is a large one and particularly timely, for co-ordinated development is the order of the day in smaller things and should be applicable on a national scale. We are glad to lend our support to the idea.

Railroads and Industrial Research

A CORRESPONDENT takes us to task for chiding the Railroad Administration on its failure to support industrial research as developed under private ownership. "Has it not occurred to you," he says, "that a man holding a bear by the tail, wishing he might let go, but afraid to do so, has no time to think of methods of animal training whereby the bear might be improved?" We confess to a mental lapse. In our zeal for the support of industrial development we overlooked the Administration's predicament. With a rapidly and steadily accumulating deficit instead of the promised surplus, it faces the unpleasant duty of raising rates and thus increasing simultaneously its revenue and unpopularity. Its earnest desire undoubtedly is to get the companies in such shape that it can relinquish its hold and pass them back to the owners—a consummation devoutly to be wished. When that time comes we can expect further attention to industrial research and development which has contributed so much to the country's prosperity.

Chemical Industry And the Victory Loan

SOME months ago we hazarded the opinion that the fourth Liberty loan would be a Victory loan, and so it proved in effect. But the expenses of making war on a huge scale were not to be stopped with the arrangement of an armistice, and so the Government finds it necessary to float a Victory loan this month.

The chemical industry has a peculiar interest in this loan, because in the act of Congress authorizing the Secretary of the Treasury to issue the notes it was provided that $1,000,000,000 should be utilized in extending credits to firms desiring to develop South American markets. Moreover, it was provided that this credit might also be extended to banks and trust companies for use in financing such trade.

We feel quite certain that the German hold on the chemical markets of the United States has been broken by the Allied victory; and thanks to the activity of the Alien Property Custodian, the German-controlled chemical firms in this country have been transferred to American buyers. The domestic field is again open to the local industry. But a domestic field is not going to be large enough to absorb our products, and foreign markets must be opened, exploited and held. The infant chemical industry of the United States can scarcely expect to invade Germany; and England, France and Italy will not permit much European competition from American chemists. South America, however, will be open to us. The former German hold there has been shaken, and in the next decade South America will be one of the important commercial battlegrounds of the world. With the financial aid promised from this Victory loan, it would seem as though American chemical industry should secure its full share of the business in the southern markets. For this reason chemists everywhere should take not only a vital interest in the success of the loan but also an active part in the campaign.

The Philosophy of Buying At Present High Prices

PROFESSOR IRVING FISHER of Yale University made an address before the Conference of Governors and Mayors at the White House on March 3-5, on "The New Price Revolution." The substance of his address was that prices have gone up for keeps, and there's no use waiting for them to go down, because they will not. Business, he said, is stalled and depression threatens because, well, to use a familiar expression which Dr. Fisher didn't, business is on the spring-board, swinging its arms but afraid to jump in. The merchant, he said, is selling, but not buying. The belief that prices will drop is putting a brake upon the entire machinery of production and distribution. Readjustment waits, because we keep on waiting for it.

The speaker is a man of vision and ingenuity, and he is very often right. He insists that we are on a permanent higher price-level, and he holds that the sooner the business men of the country take this view and adjust themselves to it the sooner will they save themselves and the nation from the misfortune which will come if we persist in the present false hope. The general level of prices, he says, is dependent upon the volume and rapidity of the turnover of the circulating medium in relation to the business transacted by it. "If the number of dollars," he explains, "circulated by cash and by check doubles, while the number of goods and services exchanged thereby remains constant, prices will be about double."

This seems to us a good definition of high prices, rather than an explanation of how they came about, but he adds that new money is what causes the increase. He notes the price revolution in the Sixteenth Century, due to the influx of gold and silver from the New World. Prices went way up, and people talked then of a temporary inflation, just as they do now. Similar sequelæ attended the increases in gold production in 1896 and 1914.

We have not space to include his review of the credit situation, except to note that the gold supply of the United States as a basis for credit has increased to such an extent that the ratio of gold to credit has risen since 1914 from 9.6 per cent to 15.3 per cent. The credit instruments of 1918 he records at $11,700,000,000, and notes that there is free gold to support a superstructure of 70 per cent as large as the existing one. He claims that the gold will not return to circulation, nor will there be a great outflow of gold through international trade. The hope that a resumption of international trade will lower prices is found to be false because European prices have risen more than ours, and they are no more likely to fall there than here.

DR. FISHER holds that there will be a vast increase of deposit banking in Europe; that the war has already brought money out of hoardings and into banks. A

consequent expansion of media of exchange will therefore take place, even in such faraway countries as India and China, which means a new habit leading to credit expansion and higher prices. This discovery of deposit banking in these countries is equivalent, economically, to a new source of gold supply.

Finally, DR. FISHER holds that to talk reverently of 1913-14 prices to-day is to speak a dead language; that new price-levels are a stubborn reality, and that the sooner merchants and manufacturers begin to stock up the better it will be all round.

Chemistry, Metallurgy, And the High Cost of Living

THE complexity of modern life and the interdependence of science and industry make it difficult at times to segregate cause and effect or see their true relation. We cannot escape, however, the close connection among chemistry, metallurgy and the cost of our daily food, nor the responsibility that devolves upon representatives of those sciences in contributing to human welfare and happiness. President TONE did well, in his address as retiring president of the American Electrochemical Society, to direct attention to the human aspects of electrochemistry, for in the last analysis the success of that or any other industry lies in the degree to which it satisfies human desires or makes possible the wider enjoyment of the fruits of labor.

The situation may be illustrated with one or two instances that will make clear our obligation. Modern agriculture calls for more intensive cultivation of the land and a larger unit yield of crops. This means artificial fertilization and the substitution of mechanical for horse or man power. It means fixed nitrogen and tractors, available phosphate and rapid transportation, potash and electrical devices. It means chemistry, electrochemistry, metallurgy and electrometallurgy moving together hand in hand, ramifying throughout the entire agricultural industry. Upon the chemist and electrochemist devolves the duty of so perfecting the processes of making fertilizer that it will be cheap enough for widespread use. Upon the metallurgist and electrometallurgist must fall the burden of providing machinery makers with metals and alloys that are at once light, strong and inexpensive so that mechanical devices will become the farmer's common servants. With cheap fertilizer yielding increased crops at lower unit costs, and power appliances replacing the efforts of many men, food must appear in increased abundance and cost less to the consumer. Thus the cycle of achievement and service is completed, and the common good advanced.

A Resolution Of Forces

IT IS interesting to note how many of the after-war problems can be viewed as a resolution of forces, old forces being in play as well as many new ones. The steel industry is seeking an alignment, which will be the resultant of various forces. The ultimate value of the dollar will be the resultant of very many forces.

In the steel industry an ethical question has been presented: Who shall take responsibility for the overhead? The Redfield board, faced with some "cost sheets," decided that certain prices for finished steel, including rails, were fair. The Railroad Administration, presumably by having scrutinized reports of steel company earnings in 1918, regarded the prices submitted as altogether too high. Anticipating a period of relatively light demand for steel, the steel producers desired prices that would take care of their overhead, just as they did in 1908, while the Government is interested in seeing a maximum amount of labor engaged in productive occupation.

In the matter of steel prices there are forces pulling in diametrically opposite directions, and that is true not only of steel but of many other commodities. On the one hand there is a low purchasing power for the dollar, whereby it costs a great deal, measured in dollars, to produce steel. On the other hand there is a great mass of equipment in the United States, in bridges, buildings, factories, transportation systems and other things, which cost certain amounts to establish, measured in the old value of the dollar. If the value of these facilities is to be measured only by the same number of dollars as formerly, then there is little opportunity for the investor to create new facilities to compete with the old, as his investment will be so much greater. Hence he is indisposed to buy steel, and there is a force tending to bring down construction costs so as to make the competition feasible, in other words to increase the purchasing power of the dollar, while on the other hand there is a force tending to increase the nominal value of the facilities existing, whereby they will be valued by a larger number of the existing dollars than formerly. The situation is so plainly recognized that many corporations have only been awaiting a decision of the Supreme Court as to the taxability of stock dividends, in order to decide whether they shall issue such stock dividends, whereby the number of dollars to be represented by the plant investment would be increased, and with the same dividend rate a larger number of dollars would be distributed to the individual stockholder, each of which dollars would buy less, when the stockholder spends it, than before the war. The alternative, to pay much larger percentage dividends, is naturally not favored, as likely to arouse criticism on the part of those indisposed to admit that the lowering of the dollar's value is permanent, or who know nothing about such economic questions.

There must be an adjustment whereby the purchasing power of the dollar and its intrinsic value will be identical. Property values will increase to an extent, while commodities, labor, the ephemeral things that are bought, will decline. When harmony is established, or the forces are resolved, the adjustment will not be permanent. The experience after the Civil War is particularly instructive. An adjustment was reached, which lasted for several years, but there was extravagance, too much conversion of liquid into fixed capital for the permanent requirements of the country, and eventually a five years' industrial depression of great severity set up a new standard, which was too far in the opposite direction. There are quickly acting and slowly acting forces. Those who now think it will require a long time to readjust, to reconstruct the economics of things so that business will function, will be surprised at the shortness of the time, while those who feel that everything can be readjusted in short order will have their surprise later, when they find that the readjustment does not prove permanent, that slowly acting forces get in their work through a period of years.

Readers' Views and Comments

The Bradford Process of Preferential Flotation

To the Editor of Chemical & Metallurgical Engineering

SIR:—The recent article of Mr. Guy C. Riddell[1] on the Bradford process of preferential flotation prompts me to make a few remarks concerning the theory of his process. The facts are, as brought out in the article referred to, that sulphur dioxide does effect a wetting of the sphalerite without any apparent chemical action. since the mineral can be restored to its original condition by subsequent exposure to air or by agitation and aëration after the removal of the sulphur dioxide. It is also true that the effect of this agent is to remove the "gaseous envelope" from the sphalerite, but not from the galena and pyrite. The question of why the sphalerite only is affected has not, however, been answered, and this is the crucial point for any extensions of the process to other minerals or other addition agents. I shall present here a brief theory of this preferential action and indicate the possibilities of extending the process.

To begin with the "gaseous envelope" or adsorbed gas on most minerals with which we have to deal is air. In certain special cases it may be in part sulphur dioxide or hydrogen sulphide, but as the minerals have been generally exposed for considerable time to a gas atmosphere in which the partial pressures of all gases except oxygen and nitrogen are exceedingly small, it is reasonable to assume that these form the normal gaseous envelope. This envelope is the same on all minerals and there is no self-evident reason why sulphur dioxide or other addition agents should remove it from one more than from another. It is true, however, that sphalerite itself is much more soluble than galena or pyrite and hence will react with a bath containing a much lower concentration of acid. We may postulate, then, as the primary preferential reaction

$$ZnS + H_2SO_3 = ZnSO_3 + H_2S$$

or if the bath is acidified with sulphuric acid, the reaction

$$ZnS + H_2SO_4 = ZnSO_4 + H_2S$$

These reactions would not take place with galena or pyrite.

It can now be shown that hydrogen sulphide is adsorbed much more readily by sulphide minerals than is air. Some unpublished experiments of Bajoulian[2] show that galena, sphalerite and chalcocite through 80 mesh take up several times their volume of hydrogen sulphide in a few hours. The hydrogen sulphide liberated by the above given preferential reaction would then displace the adsorbed air and the net effect would be sphalerite with adsorbed hydrogen sulphide and galena and pyrite with adsorbed air. A secondary reaction would then take place by which the hydrogen sulphide would be removed from the sphalerite thus:

$$2H_2S + SO_2 = 2H_2O + 2S$$

The sphalerite would accordingly be maintained without a gaseous envelope and would be unamenable to flotation.

From this explanation it is obvious that a separation of any two sulphide minerals could be effected by using a bath sufficiently acidified to attack one and not the other, and then adding sulphur dioxide or other agent to remove the hydrogen sulphide envelope from the soluble mineral. Unfortunately the difference of solubility of the minerals is not great and they are mostly so insoluble as to require a prohibitive acid concentration.

It is difficult to arrive at any quantitative information regarding the concentration of acid necessary to attack any particular mineral, since the rate of attack is affected by the physical condition of the mineral as well as its solubility. The following table from Weigel[3] gives the solubility of several minerals in water:

Mineral	Mol liter	Gram liter
Galena, from Freiberg	1 21 x 10^{-6}	0 00029
Galena, artificial	1 21 x 10^{-6}	0 00029
Cuprous sulphide, regular	3 1 x 10^{-6}	0 00049
Sphalerite, artificial	6 63 x 10^{-6}	0 00065
Sphalerite, from Satanda	6 65 x 10^{-6}	0 00065
Greenockite	8 99 x 10^{-6}	0 00130
Millerite	16 29 x 10^{-6}	0 00148
Wurtzite	28 32 x 10^{-6}	0 00281
Pyrite, artificial	40 84 x 10^{-6}	0 00490
Pyrite, from Freiberg	48 89 x 10^{-6}	0 00587

The accuracy of these figures is questionable, since they were obtained by conductivity measurements, and it is doubtful if the sulphides dissolve in water without hydrolysis. Certainly the position of pyrite is anomalous, as it is practically unattacked by dilute sulphuric acid, which quickly dissolves sphalerite.

It is possible that an electrochemical action may take place when several minerals are present; at any rate the electromotive series of the minerals seems to more nearly represent their solubility in dilute acid. This series is, according to Gottschalk and Buehler[4]:

Mineral	Volts Against Copper	Mineral	Volts Against Copper
Marcasite	+0.37	Metallic copper	0 0
Chalcopyrite	+0 30	Sphalerite	−0 2
Pyrite	+0 18	Stibnite	−0 2
Galena	+0 15		

According to this series the minerals lower in the table would exert a protective action toward those higher up. Thus in a mixture of pyrite, sphalerite and galena, the sphalerite alone would be dissolved and in fact at a much faster rate than in the absence of the other minerals.

For our purposes we may divide the minerals into two classes, those which give off hydrogen sulphide with dilute acid and those which do not. The following table gives these classes, the data being taken principally from Dana:

MINERALS ATTACKED BY DILUTE ACID		MINERALS NOT ATTACKED BY DILUTE ACID	
Sphalerite	Marcasite	Bismuthinite	Bornite
Greenockite	Zinkenite	Realgar	Chalcopyrite
Stibnite	Jamesonite	Orpiment	Pyrite
Pyrrhotite		Molybdenite	Cobaltite
		Galena	Pyrargyrite
		Argentite	Tetrahedrite
		Chalcocite	Stannite
		Cinnabar	

The minerals which do not give hydrogen sulphide with acids include, of course, also minerals that are not sulphides, and no separation can be made among them by the Bradford process. The minerals which are soluble in dilute acid should, however, be easily separable from one or more of those not soluble. Separation

[1] CHEMICAL & METALLURGICAL ENGINEERING, Dec. 15, 1918.

[2] A thesis done under my direction at the University of Pittsburgh.

[3] *Zeit. Phys. Chem.*, 58, 293 (1967).

[4] Economic Geology, 7, 15 (1912).

among the soluble minerals could also be effected if the right concentration of acid were selected.

Some of the separations suggested as possible by this theory are pyrrhotite from chalcopyrite, pyrrhotite from gold, stibnite from galena, stibnite from sphalerite, sphalerite from greenockite, sphalerite from chalcopyrite, etc.

It is possible to conceive of various extensions to the Bradford process proper; for example, in a mixture of an insoluble sulphide and a mineral other than a sulphide, the two could be treated with hydrogen sulphide and the air on the sulphide mineral displaced, while if the treatment was not too long the air would remain on the other mineral. This mixture should then be separable by the Bradford process.

It should further be possible to replace the sulphur dioxide with any substance that would react rapidly with the hydrogen sulphide. This has been done in Minerals Separation patent 10478 (English), which calls for the use of chlorine or hypochlorites.

REGINALD S. DEAN.

American Zinc, Lead & Smelting Co.,
Research Department,
St. Louis, Mo.

Recovery of Potash

To the Editor of Chemical & Metallurgical Engineering

SIR:—Referring to the letter published in your issue of April 1 by Mr. N. H. Gellert in regard to potash recovery, in which Mr. Gellert contrasts the results set forth by Mr. Linn Bradley and myself in our respective articles published in CHEMICAL & METALLURGICAL ENGINEERING of Sept. 26, 1918, I may say that since that date other data have been assembled which show that some of the statements made then by Mr. Bradley and myself should be modified more or less in the light of later results. These modifications would primarily include, (1) cost of operating a Cottrell precipitator, and (2) loss of potash in the slag.

With reference to the cost of operating a Cottrell precipitator at a 200-ton iron blast-furnace, it may be stated that the figures covering operating cost published by Porter[1] for a 3000-bbl. cement plant would apply approximately for a 200-ton iron blast-furnace. Porter's figures, which are quoted in my article referred to by Mr. Gellert, are as follows:

Labor	$27.00	per day
Power	25.00	" "
Repairs	8.00	" "
Laboratory	4.00	" "
Total	$64.00	" "

Total cost per annum $23,360; but let us make it $25,000.

Porter also shows that operating on a mixture averaging about 1 per cent K_2O, on the basis of a selling price of $1 a unit (although present prices are much higher), the operating profit per annum would amount to about $65,300. It would, therefore, be interesting to know how Mr. Gellert gets at his operating cost of $42,000 per annum for a 200-ton blast-furnace. I cannot see that he would employ a larger and more expensive precipitator, more labor, more power, or require more extensive repairs than would be necessary for a precipitator capable of handling the dust of a 3000-bbl. portland cement plant, where the actual operating cost is less than $25,000 per annum. Deducting royalty, however, Mr. Gellert's figures may not appear to be about $17,000 too high, as they would otherwise, estimating, according to his figures, the cost of operating at $42,000; or, $45,000 too high when he estimates that it would amount to $70,000 per annum. It would, therefore, seem to be largely a question of how large a percentage of these figures is assigned to royalty.

In saying this I of course realize that the operating cost of $165,000 given in my article of Sept. 26, 1918, might appear absurdly high, unless it be remembered that these figures also included certain royalties, which were then but tentatively established. Then, too, at that time potash was selling on a $5 per unit basis. Also at that time no continually operating installation of a Cottrell precipitator had been made at any blast-furnace; and these figures were intended to be ultra-conservative, and were based upon investigations, rather uniform and rigid ideas as to royalties, etc., and work done by the Research Corporation. Nevertheless, the present writer at that time accepted these figures, but that he held certain mental reservations concerning them is evidenced by the fact that in the same article he pointed out under "Estimated Costs and Recoveries" the fact that where the materials treated have the same potash tenor, operating costs and recoveries for a 200-ton iron blast-furnace would approximate those of a 3000-bbl. cement plant.

But right here it should be stated that Mr. Gellert's discussion emphasizes—though he doesn't mention it directly—a most important point in regard to royalties in that, as different percentages of recovery would be had in case of variations of potash and other content of different ores, therefore a high and rigid royalty which might readily be paid in one case would not apply in another. This, however, has been recognized and suitable royalty adjustments to fit each particular case have now been made. Data assembled by the present writer since his previous article was written have demonstrated most conclusively the very point that Mr. Gellert brings out, namely, it is not correct to assume that the same percentage of slag "would be potash for different ores." The possibility of the recovery of potash from ores lean in potash is accordingly made much more attractive than but few persons six months ago would have been willing to admit that the data then available indicated. This thought, in which there is possibility of much fallacy and many absurdities, must not, however, be carried too far.

In my article of Sept. 26, Cambrian ores, red ores and brown ores are each treated separately, the idea being to show the yields and results to be anticipated if each ore be employed alone. As a matter of fact, blast-furnace practice in general is to mix either Cambrian gray ores with limey red or Clinton ores, or to mix brown ores with these limey Clinton ores. This general furnace practice is, of course, known to everyone familiar with furnace operation in the South; and hence final results should be sought upon a basis of the proper admixture of red ores with brown, or of red with the Cambrian gray. In this connection it would be interesting to know whether Mr. Gellert's figures are based on any of these admixtures.

Mr. Gellert brings out a point of very great interest when he calls attention to the fact that certain of the brown ores in the South run "about or close to 1½ per

[1] "The Recovery of Potash as a By-Product in the Manufacture of Portland Cement," by John J. Porter, vice-president and general manager of the Security Cement & Lime Co., Hagerstown, Md.

cent potash." If this statement can be shown to apply to any considerable number of important brown ore deposits, the potentialities that would thus be indicated would be very great indeed. It would also be both interesting and well worth while to ascertain the zinc content of these same brown ores.

The present writer regards Mr. Gellert's discussion of the articles referred to as having been most helpful. He finds that he differs from Mr. Gellert chiefly as regards the cost of operating a Cottrell precipitation installation; and although he considers that perhaps Mr. Gellert's figures are too high, at the same time he must himself acknowledge having similarly been in error in presenting without direct criticism the apparently excessively large operating cost to which Mr. Gellert alludes, which cost, though, since it included tentative royalties based on $5 potash, is not really as high as it might at first appear. Naturally, in the light of more recent experience and in the absence of this explanation, the cost referred to is justly open to criticism. Hence it would seem that perhaps both of us might be subject to criticism in the cases here cited for not having itemized our cost, as well as for treating royalties as a part of operating cost, as in the instance just mentioned. My belief is, therefore, that when all these facts are taken into proper consideration our results may really be quite closely in accord. For that reason it seems more advisable to follow Porter's plan as to this, because where different and undesignated royalties are included under operating cost, confusion is almost certain to result, as, for instance, in the case under consideration.

It should always be borne in mind that two royalties are to be included, one for gas cleaning alone and another for valuable products collected. In certain instances the latter may amount to little or nothing, but the service for gas cleaning is always highly valuable. Obviously, though, the royalty for gas cleaning should not be charged against the recovery of valuable by-products, but rather against the cost of furnace operation, since the Cottrell processes make for greatly increased efficiency and economy in furnace operation regardless of the recovery or non-recovery of valuable by-products.

In conclusion, I should say that one of the things which has prevented installation of Cottrell processes at iron blast-furnaces is the widespread impression that the cost of precipitators is very high. According to the Research Corporation, the approximate cost of a precipitator is $1 per cu.ft. of gas treated, making the cost of installation at a 200-ton blast-furnace about $50,000. If electrical equipment be included, the cost of a 2-unit precipitator for a 200-ton blast-furnace would, according to the Research Corporation, "be in the neighborhood of $55,000 to $60,000." We find, however, that by using materials equally as suitable, though less expensive than those called for in the specifications issued by the Research Corporation, the initial cost of a Cottrell installation may be very materially reduced.

On this subject, just as soon as the opportunity is afforded, the present writer will be able to present certain data of a detailed nature which should prove quite helpful to those who plan to make Cottrell installations.

J. S. GRASTY.

Charlottesville, Va.

Heat Treating of Shells

To the Editor of Chemical & Metallurgical Engineering

SIR: The paper by Mr. J. M. Hall read before the Steel Treating Research Society at Detroit on heat treatment of shells, reviewed in your Feb. 15, 1919, issue, is a surprise as to its longevity.

The method of treatment should have been challenged in the meeting at the time of the birth of this paper. The treatment could not possibly be applied to 155-mm. high-explosive shell and have a ghost of a chance to pass the physical requirements of the U. S. Ordnance Department, and it is a blessing in disguise it was not widely published in this country, leading American shell manufacturers into trouble by adopting such procedure.

The method is not only extremely crude, but is misleading as well. Heat treating conducted as indicated in the paper permitting a range of temperature for quenching of 200 deg. F. (from 1500 to 1700 F.) and a range of 400 deg. F. (from 950 to 1350 F.) for drawing, on steels having a carbon range of only 0.15 per cent and a manganese range of 0.4 per cent is something unheard of here. It surprises me that even the very liberal British specifications would permit such practice.

Such treatment as that quoted—annealing 60 per cent carbon steel at 1600 deg. F. to reduce the ultimate tensile strength 7000 lb. and increase elongation 6 per cent—is absolutely unreliable and indicates vague knowledge of the condition of the treated steel. The same holds true for the practice of raising the ultimate tensile strength by air cooling from 1550 to 800 deg. F. in 7 minutes. The proper treatment of the steel would have given the desired properties.

Twin City Forge & Foundry Co., Stillwater, Minn. W. J. MERTEN.

Large vs. Small Electric Furnaces

To the Editor of Chemical & Metallurgical Engineering

SIR:—I was much interested in reading Mr. Bardwell's communication in the Dec. 1 issue of this journal on relative efficiencies of various sized electric furnaces, but my experiences do not agree altogether with those published by him. I have in mind two plants, operating 3-phase electric shaft furnaces on the same kind of alloy, one of about 2000-kw. capacity and the other consuming approximately double that amount of energy at a voltage but slightly higher. The average power consumption on the large unit was but 7 per cent less than that of the smaller unit per gross ton of metal produced.

Of course the big problem in the manufacture of ferro-alloys is the reduction of the volatilization losses. Even though the cost of ingredients may not compare with the cost of manganese ore, nevertheless a general reduction in volatilization losses means a corresponding reduction in power input, resulting in a decrease in production cost. However, there are minor problems that are common to most furnace operations and affect the final cost of production in varying degrees. One of these is the reduction of electrode consumption. I wish that Mr. Bardwell had given some data on the variation of electrode consumption with variation of voltage. It is my prediction that with higher voltages, at least up to a certain limit, there will be a decrease in the amount of electrodes used per ton of material produced. R. E. BAKER.

Keokuk, Iowa.

Western Chemical and Metallurgical Field

Working Conditions in the Zinc Smelters of the Gas Belt

HASTILY gathered statistics of zinc smelters in the gas belt (Kansas, Oklahoma and Arkansas) show a present gross retort capacity of about two-thirds the maximum number capable of operation at the peak of war production. Table I gives the figures, the capacity in 1917 being taken from a table published in the *Engineering and Mining Journal*, Vol. 107, p. 58, while the figures for 1919 are approximately correct, an asterisk marking the doubtful entries. The difference between the first and second columns really represents the number of retorts abandoned from a failure of natural gas supplies, while the difference between the second and third columns represents the stagnation in the present zinc market. Hardly one-half of the available retorts are now running, this figure amounting to approximately one-third the number during the war.

Practically all of the operators have been struggling against the inevitable for the last 18 months. During this time the zinc market has been perilously near the cost of production, if not actually below it, with the result that even the most favorably placed works have gradually curtailed. In this period only one plant has added to its capacity, namely, the Athletic Mining & Smelting Co., at Ft. Smith, Ark. The reason why this is true is apparent. Before the war 5c. was considered a fair price for zinc—when it dropped to 4.5c. many of the smelters drew their fires. Taking the reasonable figure of 60 per cent as the increased cost of manufacturing during the last year, the danger point corresponding to 4.5c. is now 7.2c., a figure below which the metal has been for some time.

Smeltermen in the gas belt have shared in the general increase in war-time wages. No general wage scale holds for this region—rates at neighboring plants in the same town may vary as much as 3c. per hour. Thus during 1917, first chargers received anywhere from $3.75 to $5.25 per day, while common labor ranged from $2 to $3. However, in the Tulsa region no less than six increases in wages were posted since May, 1914, increasing that of common labor from $1.75 for 12 hr. to $3.45 for 8 hr., the change in shift being made in July, 1917. Unfortunately these were mostly "flat increases" rather than percentage raises; the result was the reduction of the differential betwen jobs to such a point as to remove the incentive for a workman to take the harder, better or dustier jobs.

Notices of reduction in wages were posted in practically all plants on April 1, ranging from 10 to 15 per cent, in many instances so designed to establish the old differentials between skilled workmen and laborers. Dividing the number of men on a block by their aggregate daily wage, the following rates hold at a representative plant:

Average rate in 1914	$2.285
Rate in January, 1919	4.180
Posted rate April, 1919	3.626

The latter rate is 55 per cent higher than before the war, and represents about the same purchasing power. However, the workday is now universally 8 hours.

Smeltermen at all the unionized plants working under agreements accepted the decrease under protest, and these plants continue, pending an appeal to the national headquarters of the union. However, workmen at the Bartlesville Zinc Co.'s two plants in Bartlesville and at the United States Zinc Co. in Sand Springs have struck, and these plants are now under dead fire. Union organizers are busy and the problem of recognition of the new unions will probably loom larger than wage scales.

TABLE I—ZINC SMELTING CAPACITY IN GAS BELT

Company	Location	Capacity 1917	Capacity 1919	Running March, 1919
American Zinc, Lead & Smelting Co.	Dearing, Kans.	4,480	Dismantled	.....
American Zinc, Lead & Smelting Co.	Caney, Kans.	6,080	6,080	.....
American Zinc, Lead & Smelting Co.	Neodesha, Kans.	3,760	3,760*	.....
Arkansas Zinc & Smelting Corp.	Van Buren, Ark.	3,200	3,200	2,400*
Athletic Mining & Smelting Co.	Ft. Smith, Ark.	1,664	2,400	2,400
Bartlesville Zinc Co.	Bartlesville, Okla.	8,640	8,640	4,608a
Bartlesville Zinc Co.	Blackwell, Okla.	9,600	9,600	4,800
Bartlesville Zinc Co.	Collinsville, Okla.	13,440	Dismantled	.....
Chanute Spelter Co.	Chanute, Kans.	1,280	Dismantled	.....
Eagle-Picher Lead Co.	Henryetta, Okla.	3,000	3,000	3,000
Edgar Zinc Co.	Cherryvale, Kans.	5,040	5,040	4,536
Ft. Smith Spelter Co.	Ft. Smith, Ark.	2,560	2,560	2,560*
Henryetta Spelter Co.	Henryetta, Okla.	3,000	?	?
Iola Zinc Co.	Concreto, Kans.	660	Dismantled	.....
Joplin Ore & Spelter Co.	Pittsburgh, Kans.	1,792	Dismantled	.....
J. B. Kirk Gas & Acid Co.	Iola, Kans.	3,440	3,440*	.....
Kusa Spelter Co.	Kusa, Okla.	9,120	9,120	3,050
Lanyon Smelting Co.	Pittsburgh, Kans.	448	448	.....
National Zinc Co.	Carlesville, Okla.	4,256	4,256	3,648
Pittsburgh Zinc Co.	Pittsburgh, Kans.	910	910	.....
Prime Western Spelter Co.	Gas City, Kans.	4,866	Dismantled	.....
Quinton Spelter Co.	Quinton, Okla.	2,016	2,016	1,008*
Tulsa Fuel & Manufacturing Co.	Collinsville, Okla	6,232	6,232	2,816
United States Smelting Co.	Altoona, Kans.	4,640	Dismantled	.....
United States Smelting Co.	Chetopah, Okla.	5,120	5,120	.....
United States Smelting Co.	La Harpe, Kans.	1,926	Dismantled	.....
United States Zinc Co.	Henryetta, Okla.	2,400	2,400	2,400
United States Zinc Co.	Sand Springs, Okla.	8,000	8,000	3,200s
Weir Smelting Co.	Caney, Kans.	1,920	1,920	1,920
Weir Smelting Co.	Weir, Kans.	448	Dismantled	.....
Totals		123,938	88,142	42,346

Surplus Government Supplies

Copper.—The United Metal Selling Co., representing the copper producers, will sell for the War Department approximately 100,000,000 lb. of copper, at the rate of not less than 5,000,000 lb. per month for a period of ten months and 10,000,000 lb. per month for the next five months. The copper will be sold at market prices, as determined by the average quotations in the *Engineering and Mining Journal*.

Caustic Soda and Soda Ash.—As the surplus of soda ash is only 2,500 tons, this will be sold through the various selling bureaus at current market prices. The amount is so small in comparison with normal consumption that no effect on the trade is anticipated. The surplus caustic soda, 4,000 tons, will probably be disposed of through the manufacturers, so that none will be placed on the market by any of the agencies of the War Department.

Proposed Pan-American Commercial Conference

The Governing Board of the Pan-American Union has voted to hold, under the auspices of the Union, an informal Pan-American Commercial Conference during the last week of May or the first week of June, 1919, in Washington, D. C. It is expected that about 1000 delegates will attend and that the sessions will be addressed by the President, members of his Cabinet, Latin-American Ambassadors and heads of various Government boards and commissions. A complete record of the Conference will be published by the Pan-American Union as a useful handbook of Pan-American trade. The success of a similar conference in 1911 is assurance that the contemplated conference will be a marked success.

JOSEPH ESREY JOHNSON, JR.

An appreciation

By Bradley Stoughton

MR. JOSEPH ESREY JOHNSON, JR., had already gained rare distinction as an able metallurgist, clear thinker, brilliant author and wise consulting engineer to bankers and operators and had achieved the essentials of a great career when death cut short his activities on April 4, 1919, in the forty-ninth year of his age. He belonged to a family of iron blast-furnace men and mine managers. His father, Major J. E. Johnson, after serving with distinction in the Army of the North, identified himself with the iron mines and blast-furnace at Longdale, Va., with which he was connected during almost his entire business life. It is significant that during those troublous times of reconstruction in the South, he enjoyed always the affection and respect of his neighbors and associates alike. From him his son obtained not only a thorough training in blast-furnace practice and iron mining, but great personal courage and force of character. His mother, who survives both her husband and sons, possesses rare intellectuality, humor, and a tenderness and human sympathy which those who were privileged to know well J. E. Johnson, Jr., recognized beneath his exterior of aggressiveness and will power.

JOSEPH ESREY JOHNSON, JR.

In a recently published analysis of the qualities which characterize the world's great men, three traits stand out preëminent, viz., independence, courage and intellectuality. Each of these characteristics J. E. Johnson, Jr., possessed in extraordinary degree. His early education was obtained under a private tutor at Longdale, and this circumstance probably enhanced a natural tendency to independence of character and individuality which, however, under the control of his unusual power of straight thinking and clear analysis never allowed him to go far astray. It has been said of him that if once he set his mind to a problem, however knotty, he scored a bullseye before the subject was dropped.

His manner of attacking a subject involved first mastering the details of the present available knowledge; then putting this acquired information to one side with an untrammeled mind, blazing out a path of his own, so clear, so well-defined, and expressed in such simple terms that he illuminated the whole subject without distorting the original data or discussion. His two books on the iron blast-furnace together form the most comprehensive, the most enlightening, and the most useful treatise on the subject ever produced in any language.

But his ability did not end with the mastery and elucidation of principles enunciated by his predecessors. His own discoveries and inventions in the metallurgy of iron have established his reputation in every civilized country where iron and steel are made. The three most important of these, doubtless, are his thermal theory of the iron blast-furnace, which ranks with Sir Lowthian Bell's chemical practice of the iron blast-furnace as one of the two greatest scientific advances in our knowledge of the art; his original classification of iron and steel as an unbroken series of alloys of iron and carbon; and his discovery that oxide, instead of being the unmixed evil which it was accredited in the minds of most metallurgists, actually benefited the strength of cast iron.

There are many stories told of Esrey Johnson's personal courage, but probably the most spectacular one is the prevention of an attempted lynching in Virginia in 1909. A young white girl had been murdered by a colored boy under those horrifying circumstances with accounts of which we are all too familiar. Johnson was not only manager of the mines and blast-furnace of the locality, but was one of the officials of the county. He organized the search whereby the negro was captured, brought to Johnson's office and a confession of the crime wrung from him. The usual crowd collected quickly, thirsting for vengeance in the form of hanging or burning. Practically alone, Johnson held this crowd at bay for several hours, sometimes mixing with the crowd and pledging his honor that the colored boy should be tried and executed according to law, sometimes pleading for the good name of the community, and when necessary, "showing his teeth" to those who can understand no other argument for the curbing of their personal inclinations or intentions. He has told me that he expressed himself in substantially these words: "I am going to see this nigger hung in accordance with law and order. If you fellows try to prevent me, you may get me, but I will get some of you first." I am sure that at this point in the argument he smiled, for he had a very expressive smile which endeared his friends to him, and which he could make very convincing when he desired. Finally, the morning train arrived on the track just outside Johnson's office. He realized that this was the moment when a coup would be attempted, but he had already laid his plans with the sheriff over the long distance telephone. The train stopped exactly where he had directed. He rushed the trembling culprit by the crowd of angry, heavily-armed men into an empty railroad car occupied only by the sheriff. The door was barricaded behind the three men and the train pulled out before a rush could be accomplished. Another crowd had to be overawed at the entrance of the county courthouse where the judge had called a special term of the court. To him Johnson delivered his prisoner and made good on his promise that justice should be done, which it ultimately was. The story of this interesting episode is told in the *American Law Review* for November-December, 1911, under the title "Lynching Unnecessary."

Johnson led a white life. There was no weak spot in his professional or personal armor of honor and sincerity. His home life was an unusually happy and congenial one. He married Miss Margaret C. Hilles of Wilmington, Delaware, and she was not only his friend and comrade, but an intellectual stimulus and helpmate in a very busy life. She, with one boy, J. E. Johnson, 4th, survives him.

I cannot give a better summary of Johnson's professional attainments than by quoting from a letter from his friend James Gayley. These two master minds found mutual sympathy and understanding. Johnson had an unbounded admiration for Gayley, whom he describes in the dedication of his books as the "founder of modern American blast-furnace practice." Gayley made of Johnson a pupil and gave him valuable advice and assistance during the early days of his establishment as a consulting engineer in New York City. On the day of Johnson's death, Gayley wrote to me as follows:

"American metallurgy of iron has lost its shining light and the world is poorer thereby. . . . Esrey Johnson is and was the greatest man in the metallurgy of iron and the clearest thinker of any man today. He seems like a younger brother gone and none come to fill his place."

Johnson always identified himself with the public work of his profession and community. He was for many years a member of the principal engineering societies, being active in the American Society of Mechanical Engineers, the Mining and Metallurgical Society of America, and the American Institute of Mining and Metallurgical Engineers. His pen has enriched the literature of these and other societies on both sides of the Atlantic. His interests naturally brought him more closely into affiliation with the A. I. M. E., for which he served as a member of the board of directors and chairman and member of many prominent committees, including the vice-chairmanship of the iron and steel committee. Of recent years he had been active in guiding the policies of this Institute, and at the time of his death was, besides a director, a member of the executive committee and chairman of the committee on admissions.

The Engineer as a Citizen

ON Wednesday evening, March 26, the New York Sections of the American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers and Society of Automotive Engineers held a meeting at which was presented an engineers' symposium on "The Engineer as a Citizen." Local members of the electrical engineers, civil engineers and thirteen other engineering and technical societies were invited to participate.

In opening the meeting the presiding officer, MR. GANO DUNN, called attention to the fact that engineers were earnestly examining themselves and their organizations to determine what their relation should be to society. He felt that we should not be led astray into a zeal for doing things for society in general which we would not do first for our fellow engineers, and that the man is inconsistent who urges something for society which he is unwilling to do for his fellow engineer.

Civic Responsibility of the Engineer

The first speaker was MR. PHILIP N. MOORE, representing the American Institute of Mining and Metallurgical Engineers, who spoke on the civic responsibility of the engineer. Mr. Moore saw the engineer waking from a long sleep of indifference to a sudden realization of the fact that he was not politically potent. Examining the reasons for this failure of the engineer to count as a class politically, Mr. Moore found the following reasons: First, a lack of local attachment. Engineers are constantly working themselves out of a job and have little time or inclination to take an interest in local affairs. Being without local responsibilities they have a small sense of civic duty. Again the relation of the large proportion of our engineers to the great business consolidations, many of which have in the past been antagonistic to the interests of society, leads them to withhold from civic activities. Furthermore, the training of the engineer is too often merely technical and fails to give him an interest in the welfare of the community of which he is a part. The remedy for the isolation of the engineer lies within himself, and he must realize that it is his duty as well as his privilege to participate in civic affairs. Mr. Moore felt that the engineer's voice would be a potent factor in bringing the world to a realization of some elemental truths, namely, that the hand deserves not the same reward as the brain; that there is no justice in the demand of the worker to share profits unless he is also willing to share losses, and that there is no partnership where gains alone and not risks are shared; that no wages are earned which are not fully reproduced in product; that labor can be paid only from the product of its toil when that product is sold at a profit; that all products are the result of the joint effort of labor, capital and management, and that all of these must share the output.

Relation of the Engineer to Legislation

MR. CALVERT TOWNLEY, representing the American Institute of Electrical Engineers, spoke on the relation of the engineer to legislation. He reviewed briefly the efforts which engineering societies had made in recent years to influence or bring about legislation on engineering matters and showed that the policy generally had been to confine the activities of engineers to a statement of the facts and to refrain from expressing views as to the wording of any legislation or opinions on legal matters. The speaker was of the opinion that this is about as far as engineers can go because, while they will be found in close accord on fundamental engineering questions, they cannot be expected to agree on general legislation any more than any other body of educated men. He spoke of the efforts of Engineering Council to keep in touch with legislation through the National Service Committee with an office in Washington, D. C. In conclusion it was the speaker's opinion that we should not try to influence legislation which concerns us only as citizens, but that if we undertake the task at all we should concentrate on certain specific lines of engineering importance.

The relation of the engineer to administration was discussed by MR. NELSON P. LEWIS, representing the American Society of Civil Engineers. The speaker found that engineers were assuming a more important

place in the administration of large industrial enterprises, but that they have been more completely excluded from the public administration of the affairs of cities and States. Mr. Lewis asked, however, "What is the city or State but a public service corporation?" He felt that engineers should play a conspicuous part in the administration of city and State affairs. He showed how the commission government plan grew out of the Galveston disaster, and the commission-manager plan out of Dayton's experience in 1913. He felt that the engineer with executive capacity was especially well qualified to fill the position of commission-manager in city administration. At the beginning of 1919, 124 cities and towns in the United States were operating under some form of the city-manager plan, and out of 88 of these managers 50 were professional engineers, 9 merchants, 6 minor city officials, 5 general business, 3 superintendents of construction, 2 journalists and 13 miscellaneous. In conclusion the speaker felt that the trained engineer is the logical man to manage undertakings involving the planning and execution of engineering work, and that the educational preparation for such work should include a knowledge of business and administrative methods as well as a knowledge of purely technical subjects.

The Engineer and Public Opinion

Mr. Spencer Miller, representing the American Society of Mechanical Engineers, spoke on the relation of the engineer to public opinion. The speaker believed that "public opinion is not always right, but it is always autocratic." He felt that the importance of the engineer in public life was such that we should make every effort individually and collectively to mold public opinion in the right direction and especially to counteract the propaganda which tends to stir up class hatred. Many of the engineers who occupied positions of responsibility during the war will be invited to accept still larger responsibilities as public servants, and they have an opportunity to mold public opinion along the lines of honesty, integrity, unselfishness, self-control and co-operation. These qualities make the engineer successful in public life. The speaker was of the opinion that a Congress half lawyer and half engineer would be superior to one all lawyer or all engineer. Both types are needed in public and political life. The speaker felt that a good beginning toward molding public opinion would be the adoption of a code of ethics which should become the moral foundation of all engineering associations.

Production and Distribution

Dr. C. A. Adams, president of the American Institute of Electrical Engineers, closed the symposium with a discussion of the relation of the engineer to production and distribution. He departed from his subject in the beginning to say that his long experience with engineering education had convinced him that it is not the curriculum and the subjects taught that count in the making of an engineer, but that the way in which they are taught is the important matter. He believed that one could "put more spirit and more character building and more general preparation for citizenship into a course in dynamo design" than could ordinarily be found in courses in economics, history or government. The speaker then referred to the industrial situation in the world today and the part which the engineer could play in effecting a settlement between contending forces. The machinery of production and distribution is largely in engineers' hands and he thought that it could be so improved as to increase the productivity of labor and thus make possible a living wage and a fair return for capital. He felt that our present competitive methods are wasteful in the extreme, and add to the cost of production and distribution.

There was considerable discussion of the subject, with particular reference to ways in which the engineer could function in public affairs through his societies. Mr. S. N. Castle suggested that there were four methods: The merger of existing societies into one large national organization; a New York engineering society or metropolitan association of engineers to comprise the New York sections of the national societies; an association of the delegates or officers of the New York sections of the national societies; or finally, interlocking committees in the national societies. Mr. Daniel Turner felt that there was no need of organizing a new society, but that the American Association of Engineers could serve the purpose of uniting all engineers in matters relating to public affairs. Mr. J. E. Johnson, Jr., thought that Engineering Council could serve engineers better if it were more national in its scope. It was his opinion that this organization was suffering from distinguished men who had made their reputations and who hesitated to take any serious or radical steps for fear of losing what they had gained.

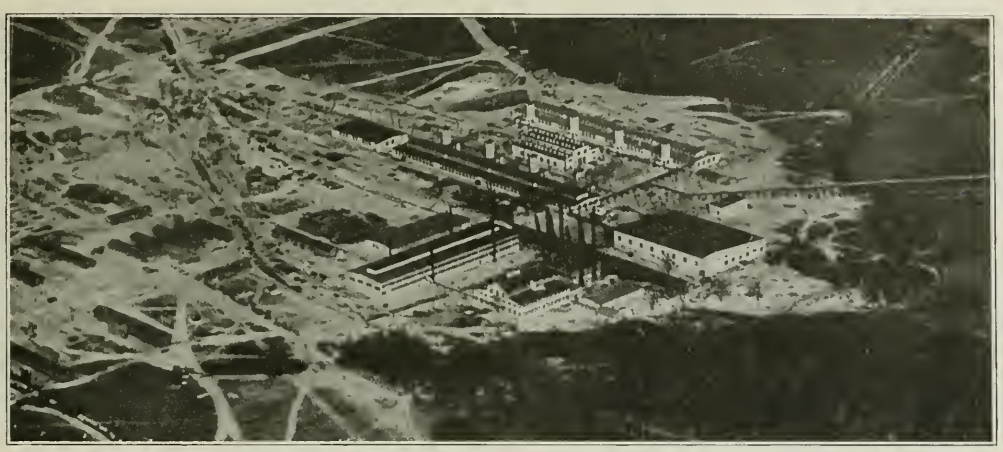
Joint Conference for Closer Co-operation

A resolution was adopted asking the various societies represented, or their local sections, to appoint delegates to attend a joint conference with a view to organizing for closer co-operation between engineers in the metropolitan district. Another resolution called upon all engineering societies of this country which have not yet appointed committees on development, to appoint such committees with instructions to undertake a survey of the aims and purposes of their respective organizations and to co-operate with similar committees of engineering societies. A third resolution called for the appointment of delegates from the societies repesented in the meeting to a conference for the purpose of discussing and formulating a proposed code of ethics for the professional conduct of engineers.

Manufacture of Phthalic Anhydride

On June 16, 1917, the Department of Agriculture announced that the Color Laboratory of the Bureau of Chemistry had developed, on a laboratory scale, a new process for the manufacture of phthalic anhydride and was ready to co-operate with manufacturers in the attempt to develop the process on a commercial scale. All of the co-operation that could be handled at that time was obtained and on Nov. 1, 1917, the offer of co-operation was withdrawn.

Inasmuch as a number of manufacturers recently have expressed a desire to produce phthalic anhydride and co-operate in the experimental work, the Department of Agriculture announces that it is ready to assist manufacturers by reopening this offer of co-operation on the same terms and under the same form of agreement as originally made with other manufacturers. This offer of additional co-operation is made possible by the release from war work of men of the Color Laboratory. It will not be held open indefinitely.



AEROPLANE VIEW ELECTROLYTIC CHLORINE PLANT, EDGEWOOD ARSENAL

New York Meeting of the American Electrochemical Society

First Post-War Meeting Marked by Symposium on Released Information Showing Part Played by Electrochemistry in the War—Election of Officers and Transaction of General Business—Excellent Financial Condition of the Society

THE thirty-fifth general meeting of the American Electrochemical Society convened at the Chemists' Club in New York City, April 3, 4 and 5. Being the first post-war meeting of the Society, there was a large attendance and ample evidence of removal of that sober restraint which the business of war had exercised over the activities of the members. Thus Section Q and its familiar pastimes were revived at a smoker with the usual success; and a trip of inspection scheduled for Saturday morning was well attended in spite of inclement weather.

Meeting of the Directors

The Directors met for the transaction of annual business and considered some important matters. The sum of $2000 was set aside for investment in the forthcoming Victory Loan, following the precedent established for previous Liberty Loans. This will make a total of $10,000 invested in Government bonds. The general financial condition was shown to be unusually good. Liquid assets aggregate $20,000, or $10 per member. Additional assets in the form of publications, which are being sold at the rate of about $2000 per annum, amount to another $20,000, or a total of about $20 per member. The membership committee reported a membership of 1928.

At the invitation of Engineering Council the directors appointed Mr. F. A. Lidbury to represent the Electrochemical Society at a meeting of the National Service Committee of the Council, to be held in Chicago April 23-25, for the purpose of promoting the establishment of a Department of Public Works in the Federal Government. Mr. Lidbury was instructed to support the movement.

A committee, not yet named, is to be appointed to co-operate with the American Society for Testing Materials on standard lime specifications.

Messrs. Cottrell and Dwight were appointed to represent the Society at a conference in Paris called to consider an inter-Allied federation of industrial chemical societies.

A resolution was adopted approving proposed legislation by the next Congress appropriating $50,000 for a water-power survey of the country by the Geological Survey, and $200,000 for a survey by the Geological Survey and the Bureau of Mines of the various sources of power in the industrial region of the North Atlantic seaboard.

Officers Elected at Annual Business Meeting

The committee on patent legislation was represented by Mr. E. J. Prindle, who presented a digest of the report prepared by the patent committee of National Research Council, with the recommendation that the Electrochemical Society approve it. This report has already been published in Chemical & Metallurgical Engineering, Feb. 15. It was approved by the Society.

The recent annual election of officers for 1919-20 resulted as follows: President, Wilder D. Bancroft; vice-presidents, J. V. N. Dorr, W. R. Whitney, Carl Hering; managers, H. C. Parmelee, R. E. Zimmerman, E. Blough; treasurer, P. G. Salom; secretary, J. W. Richards.

Oppose Government Ownership and Operation of Water Powers

The Committee on Public Relations presented a report condemning Government ownership and operation of water powers. This report met with some opposition

on account of its partisan nature, the opponents of its adoption not necessarily opposing its provisions, but feeling that it would have even more force if it was more judicial in tone and not a bit of special pleading. In spite of opposition, however, the report was adopted as follows:

"It is understood that this report does not consider the question of the Government ownership of sources of hydro-electric energy nor of Government control and regulation of hydro-electric systems; but simply operation by the Government of hydro-electric systems in comparison with operation thereof by private companies. As regards this aspect of Government ownership it is the opinion of your committee:

1. That anything which affects, either for good or evil, electrochemical industries will effect in a corresponding way the people as a whole.
2. That the inherent defects of governmental activities in industrial enterprises will be found in Government ownership of hydro-electric systems and will affect the electrochemical industries dependent on such systems adversely.
3. That the American Electrochemical Society, being interested in and representing the electrochemical industries of the United States, should strongly oppose all attempts at governmental operation of hydro-electric systems.

"It is needless to present any evidence to the members of the American Electrochemical Society that the electrochemical industries are of vast importance to the whole nation and to every individual composing it.

Even a superficial examination of numerous governmental activities shows that those which can only be undertaken by the Government leave much to be desired in their results and that when these are of an industrial nature they are invariably inefficient, uneconomical and subject to numerous glaring defects which are obviously inherent in governmental work of this kind in a democracy, when the present state of human character is considered. Under an autocratic government certain causes of the defects of such governmental activities do not exist; but, as recent experience has shown, even when the existence of a democratic nation is threatened by external aggression and a temporary reversion to autocratic government becomes necessary, governmental industrial enterprise is far inferior to private undertakings of this nature.

"It is the belief of all American citizens that governments are instituted among men to secure certain inalienable rights, among which not the least is individual liberty, and that the reason why their country has prospered so wonderfully is because those intrusted with its administration have not only confined themselves within their constitutional spheres, but have refrained from encroaching on and consequently diminishing the fields of activity of its citizens. Most of our citizens who have given the matter careful thought also believe that governmental encroachment in such fields will greatly overbalance, in permanent evil, any partial or transient benefit which it may yield.

"There is no evidence that governmental ownership of hydro-electric systems will be any freer from defects than other kinds of governmental industrial enterprise, but quite the contrary.

"Your committee believes that the American Electrochemical Society should have an opportunity to go on record as opposed to Government ownership and operation of hydro-electric systems and that this record should be given the widest publicity."

The Smoker and Inspection Trip

The smoker, under the direction of Mr. M. B. Coho, proved to be a great success. As a parody on the afternoon's program on released information, Mr. Ellwood Hendrick read a paper on Deceased Information, in which he brought forward a few delicious bits of scientific information promulgated by Pliny the Elder, who perished in the eruption of Vesuvius, 79 A.D. This was followed by an exhibit of unusual views of some members of the Society, thrown on the screen and "explained" by Mr. L. E. Saunders. The program was concluded by a view of several animated mechanical movies, by courtesy of the Bray Studios. These included demonstration of the mechanism and operation of the Lewis machine gun, the internal combustion engine and the telephone. Singing and a Dutch lunch concluded the plans for the evening.

The inspection trip Saturday morning was attended by over 100. Visits were made to the Loose-Wiles Co., the Wright-Martin Aircraft Co., and the Nichols Copper Co. Luncheon was served at the latter place by courtesy of the company.

Presidential Address and Technical Papers

The opening address was that of President Tone on "Electrochemistry in Its Human Relations," which is printed in full elsewhere in this issue.

Principles of Inductive Heating With High Frequency Currents

DR. E. F. NORTHRUP, who has recently perfected a new type of electrodeless electric furnace at the Palmer Physical Laboratory at Princeton for the Ajax Metal Co., gave the theoretical principles involved in inductive heating. He derived equations whereby rates of heating and thermal efficiencies can be obtained in quaternary circuits with e.m.f. impressed on the primary circuit, also general equations applied to a single pair of coupled circuits. In conclusion Dr. Northrup said:

"The development of electric heating with high-frequency currents and without interlinkage of an iron magnetic circuit with an electric circuit was brought by the writer to its present stage of development (December, 1918) almost entirely by laboratory experimentation. In the course of this experimental work it has been proved beyond doubt that, using oscillatory currents to secure the requisite frequency, rapid heating of a crucible and its contents may be obtained with a thermal efficiency in the neighborhood of 60 per cent, and temperatures up to 1800 deg. C. or 2000 deg. C. may be obtained. Batches of several kilograms of such materials as Pyrex glass among the non-conductors and pure iron and pure nickel among the conductors have been rapidly melted in air and in vacuum. Platinum has recently been melted without the presence of carbon in a 20-kw. furnace sold to the Baker Platinum Co.

Nature of Problems Recognized

"After these experimental results had shown the correctness of the physical ideas which led to and guided the experimental developments, the precise nature of the problems involved became more and more clearly recognized. The necessity became apparent for developing in a comprehensive way a complete theory of this method of electric heating, and of other entirely new engineering matters which develop when high-frequency currents, in connection with large amounts of power, are utilized.

"These theoretical foundations have now been laid and all the basic mathematical relations have been found which are necessary for, and will permit the design of, very large power heating units.

"For electric furnaces which require the use of 100, 500, 1000 kw. or more, it is highly probable that the best and most practical source of the high-frequency current required is, in the light of present practice, an electric generator direct connected to a steam turbine.

Voltages Required

"Practical considerations demand that the voltages applied to, and used near, the heater unit shall be well below any voltage which might be dangerous to life. The mathematical treatment proves that there is no theoretical limitation in this method of heating, either to the voltages which may be safely used or to the size of the units and the amount of power which may be employed. Theory also shows that in all cases where the high-frequency current is obtained from an alternator the supply lines can furnish power at practically unity power factor and that the possibilities of obtaining high thermal efficiencies and rapid heating and elevated temperatures are equal to or better than the results obtained in these respects by standard methods of electric heating. Futhermore, both theory and experiments have proved that uniformity in the temperature of the heated mass, perfection in the control of temperature and the ability to heat up charges from the cold with great rapidity exceed anything heretofore obtained in electric furnace practice.

Path Now Laid for Advance

"The path is now laid and the mathematical formulæ are given for the purely engineering advance in the designing of large power units for heat treatment of materials (glass, non-ferrous and ferrous metals) in tonnage quantities.

"The oscillatory current system for obtaining the required current of high frequency has not so far been utilized in power units exceeding 60 kw. The large expense of the condensers required, which are only active in the oscillatory current method from one-fifth to one-sixth of the time, the rather low power factor connected with this system and the high voltages required for generating the oscillations would seem to limit this method of obtaining high-frequency current to single power units of the order of magnitude of 100 kw.

"Two or more oscillatory current systems may be made, however, to operate in conjunction to heat a single furnace of large dimensions.

"Because, on the other hand, high-frequency currents may be obtained with oscillatory discharge with ap-

paratus which contains no moving parts and which has an exceedingly slow depreciation, this system of heating is ideally adapted to small power installations and to all kinds of laboratory furnace practice.

Larger Problem Awaits Solution

"The much larger problem, of the heat treatment of materials in tonnage lots, awaits for its practical solution the development of less expensive and more efficient means of obtaining currents of 10,000 cycles or more in limitless amounts. Intensive investigation is now in progress in several quarters looking to the development of high-power, high-frequency apparatus, and full success in this matter will mean a great and highly satisfactory solution of the future commercial heat treatment of materials in large quantity by means of the electric furnace."

Extraction of Uranium From Pitchblende

The carbide method of separation as developed by Gustave Gin and communicated to the society prior to his death was given in connection with the methods used at Joachimsthal.

The powdered mineral is roasted in a reverberatory furnace until sulphur is all removed. Almost all the arsenic is likewise removed and the uranium changed into sesquioxide.

The roasted material is mixed with carbon and put into an electric furnace with two hearths. The quantity of carbon introduced should be insufficient to reduce all the metallic oxides. The lead, copper, iron, nickel, cobalt, and perhaps a little of the tungsten, will be liberated as metals, and there is formed a slag containing silica and the lower oxides of uranium, vanadium, tungsten and molybdenum. The base metals are run off and carbon is then added to the slag in sufficient quantity to reduce the oxides and transform them into carbides.

The further treatment in the electric furnace gives a mass of carbides of uranium, tungsten, vanadium and molybdenum, which if cooled quickly on removal from the furnace can be easily pulverized. The powdered carbides are treated with water at 60 deg. C. Uranium carbide decomposes water, giving hydrated uranium oxide, green at first, but rapidly becoming blackish on contact with air. This precipitate is separated by flotation and dried and calcined. It then serves for the electric preparation of the pure metal or of its alloys or for the manufacture of uranium compounds such as the nitrate of alkaline salts.

Treatment of Residue

The residue from the treatment with water contains all the unattackable carbides and silicides. It is dried and treated with potassium nitrate to fusion resulting in a mixture of the alkaline vanadates, tungstates, molybdates and silicates. This fusion is dissolved in hot water and hydrochloric acid added. Tungstic and silicic acids are precipitated while molybdenum and vanadium remain in solution with any phosphoric acid. After filtration and washing of the precipitate tungstic acid is separated from the silica by fusion with bisulphate of potassium. The product of this fusion is dissolved in water, which removes potassium sulphate and leaves a white residue of tungstic acid and silico-tungstate of potassium. The residue is treated with cold water to which is added ammonium carbonate, dissolving the tungstic acid and leaving the silico-tungstate undissolved.

In the solution coming from the first operation and containing molybdenum and vanadium it is extremely difficult to remove phosphoric acid, and it is preferable in practice to precipitate it as ammonium phosphomolybdate. The solution is concentrated and ammonia is added until a yellow precipitate is no longer formed. Filter, and in the filtrate the vanadium present may be precipitated as ammonium vanadate by adding ammonium carbonate and crystals of ammonium chloride. The filtered liquid contains only ammonium molybdate, that is if all the molybdenum has not previously passed into the phospho-molybdate. The ammonium molybdate is obtained by concentrating to dryness and calcined in the air to molybdic acid.

Finally, molybdic acid may be separated from the phospho-molybdate by dissolving it in a concentrated ammoniacal solution and adding chloride of magnesium to precipitate the phosphoric acid as ammonium-magnesium phosphate.

Dr. S. C. Lind, Bureau of Mines, Golden, Colo., contributed a discussion in which he called attention to the radical change which had occurred in the last ten years regarding the rare elements. Pitchblende, formerly the chief ore of uranium, has been relegated to secondary importance by the carnotite of Colorado and Utah. Furthermore, uranium, formerly the principal product of the treatment of pitchblende, is now almost a by-product, with radium of primary importance. This has altered the metallurgical processes, and has brought into prominence that using an initial nitric acid leach as opposed to the older methods using sulphuric acid which throws radium into the tailings as a sulphate.

Electrolytic Silver and Gold Refining

Mr. George G. Griswold gave the following account of the Moebius process: "The first electrolytic plant for the treatment of doré bullion was put in at the Kansas City Smelting & Refining Co., Argentine, Kansas, in 1884 or 1885 by Dr. Moebius. This worked entirely satisfactorily, and was followed by other installations. The second was at the Perth Amboy plant of the American Smelting & Refining Co. These were of the Moebius vertical type. Dr. Moebius afterward patented a horizontal system with traveling silver belts for cathodes, a small installation of which was made at Perth Amboy, but did not prove as satisfactory there as the vertical type. When the parting plant was destroyed by fire, in 1897, it was decided to install the vertical system in the new plant. The decision to adopt this system was due to its greater capacity for a given floor space, smaller tie-up, and the fact that being run in connection with a lead refinery the anodes could be cheaply made 990 fine or better.

"The new tank room contains twenty-four sections of six tanks each, the sections being in series and the tanks in multiple. In the original installation the tanks were made of wood, which was never very satisfactory, and consequently stoneware tanks were used in the new plant.

The Anodes and Cathodes

"The anodes, weighing about 100 ounces, are cast by hand in the lead refinery and transferred in locked steel boxes, by a storage battery truck, to the parting plant. They are weighed, counted and punched, and are then used as required. The punching gives a slight depression on each side of the ear of the anode, thus furnishing a secure hold and better contact for the spring clips

which support them. The cathodes were made from cold-rolled silver sheets $\frac{1}{32}$ in. thick. There are 4 bags and 5 cathodes in each tank, and each bag holds 4 new anodes. Seventy-five per cent of the silver is deposited in 24 hours. It is constantly brushed from the cathodes by wooden sticks, rigidly attached to a wooden frame having a reciprocating motion, which serves to prevent short circuiting and also to give circulation. The deposited silver falls into wooden silver boxes, and is removed daily by dropping the hinged bottom of the silver boxes, which dumps the silver into a tray from which it is emptied into a wooden silver-car, provided with a false bottom and filter. The car is transferred to vacuum boxes, the silver washed, and then transferred to the melting room, where it is dried, melted, and cast into bars.

"The electrolyte is a neutral nitrate solution containing 15 to 20 grams silver and 30 to 40 grams copper per liter. Silver nitrate is added as required, and enough electrolyte withdrawn daily to keep the purity up to standard. The waste electrolyte is put in a wooden tank and the silver precipitated on copper, after which the copper is cemented out on iron and the resultant solution, after passing over lime, thrown away.

Current

"Current was supplied by an engine-driven generator in the same building and a current density of 19½ amp. per sq.ft. carefully maintained; but later it was found more advantageous to install a motor-generator set in the central power plant, and to increase the current density to 40 amp. per sq.ft., which increased the capacity accordingly. The current is carried from the switchboard by copper cables which distribute it through mercury-filled copper cups over ⅞ in. cold-rolled copper bus-bars, the end ones being bent to fit into the mercury cup when lowered into position.

"The bags which contain the gold slime are removed at regular intervals, and the contents sluiced into the gold box, thoroughly washed, transferred to iron boiling kettles, and treated with H_2SO_4, 66 deg. B., to remove the copper and silver. The gold slime is washed, dried and cast into anodes for electrolytic refining by the Wohlwill process. The liquor from boiling the slimes is run into lead-lined tanks, and the silver precipitated out on copper. The copper-bearing solution then goes to the copper refinery.

"The Wohlwill installation has five cells, and is in series with the silver sections. At the time it was put in, owing to the war, it was not possible to obtain porcelain, and stoneware cells were used. With the high current density of 150 amp. per sq.ft. osmosis develops in the stoneware; also, as they crack with any unequal strain, it was necessary to place them in a lead-lined box filled with water heated by steam coils. The boxes are supported in a lead-covered table with cupped top.

"An interesting feature is the use of mercury cups on the ends of the copper bus-bars, whereby any unit or units can be cut in or out quickly by using cross bars, also of copper. with ends bent to fit into the cups.

"The cathodes are thin gold sheets, rolled from electrolytic gold, and are connected to the contact bars by bending one end of the sheet around them and clipping them fast.

"The electrolyte contains 30 per cent free HCl, 80 to 85 g. gold per liter, and varying amounts of platinum and palladium. When the solution accumulates a sufficient percentage of these latter metals, a portion is withdrawn, and they are separated, refined and sold as pure metals."

Process for Refining Nickel

Mr. George A. Guess gave a description of a new method in which impure nickel, containing copper and iron, is electrolytically refined, using it as anode. Iron goes into solution and accumulates there, but copper, which also goes into solution, is precipitated therefrom continuously by keeping powdered calcium carbonate (limestone) suspended in the electrolyte. An unusual salt is thus formed from the copper in solution, $2CuO.2NiO.SO_3$, completely precipitating out copper, which settles, with $CaSO_4$, as a mud. The cathode is enclosed in a canvas bag to keep it free from mechanical impurities. Glue is used in the solution. The cathode nickel contains usually less than 0.001 per cent copper. The mud is reduced by fusion to a nickel-copper matte, which is dead roasted, and then reduced to nickel-copper alloy, NiCu, which is used as anode in an ordinary copper refining bath to recover its nickel as sulphate.

Referring to Mr. Guess' paper, Dr. Hering pointed out that in this case we have a suspension of solid particles in an electrolyte, and that they would migrate in a definite direction, usually with the current to the cathode. For this reason he thought it would be necessary to put a porous cell around the cathode to prevent the deposition of these solid particles, and he wondered whether the arrangement provided by the author would be effective. Mr. Hogaboom called attention to the use of glue in the electrolyte and said that his own experience was that glue produced dark and brittle deposits of nickel. He questioned the advantage of its use.

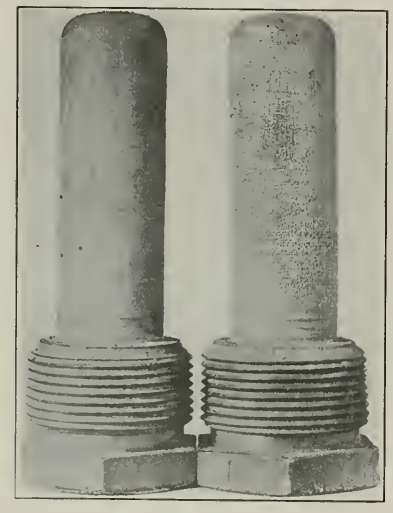
Electroplating

Mr. Oliver P. Watts reviewed his investigations on electrop'atings of copper upon iron by preliminary dipping of the iron article in solutions of various metals which lie, electrochemically, between iron and copper. Arsenic, antimony, bismuth, lead and tin dipping solutions were tried, and arsenic, lead and antimony solutions found effective in securing a good subsequent electroplating of copper. Even bismuth can be electrodeposited on iron by using a preliminary arsenic or antimony dip. Nickel can be deposited on aluminium by using a ferric chloride dipping solution. The paper will be published in a future issue.

In discussion one member related his experience with nickel-plated steel surgical tools. The plate peeled from these articles, particularly at or near the cutting edges. On careful examination it was found that there was a film of dirt on the steel wherever the nickel peeled, and investigation was made to ascertain how the dirt got there. It was believed that the dirt came from particles floating on the surface of the solution which would adhere to the steel articles when they were placed in the bath. It was also thought that these particles being submerged might be carried by the current and deposited on the articles. A preliminary copper plating was considered advisable in order to make the nickel more adherent.

Mr. Hogaboom was of the opinion that a dirt film on the surface of the bath would affect the articles regardless of a preliminary copper plate; and Mr. Reeve

doubted if the dirt came from floating particles because it had been his observation that when articles were placed in the plating bath the surface film spread when touched and thus left a clean surface through which to insert the articles into the bath. He was of the opinion that the surface of steel was such that while it might appear to be clean, it would still have pin-holes containing dirt which would prevent good plating. He said that the "water-break" test is not adequate to determine the cleanliness of a steel surface. MR. MADSEN questioned the value of a preliminary copper plate in order to make the nickel adherent. He thought that floating dirt on the bath which might become wetted and sink would migrate with the current and be deposited in the plate. He thought also that impurities in the anodes



PITTING IN ELECTROPLATING

might act likewise, and that under certain conditions of current, temperature, etc., nickel oxide might be carried across. DR. RICHARDS thought that the whole trouble of peeling on sharp-edged tools would be avoided by making them of the alloy stellite.[1]

When making some lead platings, Mr. Watts observed that heavy pitting suddenly and irregularly appeared. After considerable study of the cause, it was finally found to be due to air dissolving in the electrolyte while it was resting over night and cooling, which was then expelled as minute air bubbles on the work when the bath was heated up by the passage of the current. The microscopic bubbles clinging to the work, which had been left immersed in the bath, started the pitting.

The difficulty was overcome by heating the solution to a little above its working temperature by means of a lead steam coil before resuming plating, whenever the tanks had been out of use for any considerable time.

MR. HOGABOOM reviewed his experiences with pitting in electroplating and exhibited a piece of silver plating on glassware which he had made many years ago. Various experiences and experiments confirmed him in the belief that the pitting was due to air in the solutions, particularly the surface layer of the solution in the vat. He thought that lead deposits were affected more than other metals by air in the plating solution.

[1]See this journal, May 15, 1918, p. 541.

Notes on Electrostatic Precipitation

MR. H. D. BRALEY reveiwed electrostatic separation of particles from gases and emulsions. The various applications discussed are: Recovery of metallic dust, of antimony, sulphur and arsenic, of potash, of sulphuric acid fumes and the dehydration of aqueous oil emulsions. Accounting data obtained from the International Smelting Co. show that the process has unquestionable financial merits. Separate discussions are given regarding the construction and operation of various types of treaters, temperature control as affecting operation, gas velocity during treatment, direction of gas flow, capacity of electrical supply, operating voltage, apparatus, transformers, generators, synchronous motors, rectifiers and accessories.

In discussion of this paper DR. DUSHMAN expressed the belief that the kenotron was more practical in current rectification than indicated by Mr. Braley. The operating temperature of the filament is about that of the ordinary incandescent lamp—far below the melting point of tungsten. He stated that the research laboratory of the General Electric Co. had perfected a control panel which protected the kenotrons against high-voltage stresses. The basic difference between the kenotron and the mercury-arc rectifier is that the former can be operated in parallel to get any quantity of power, which is not possible with the mercury-arc. Further, the kenotron can be operated up to 150,000 volts, and reduces to a minimum the surging in the precipitator circuit. He showed oscillograms of kenotron operation in comparison with mechanical rectifier operation, taken in co-operation with the Research Corporation. These portrayed the peculiar characteristics of the circuit of the Cottrell precipitator, one feature being the flattening effect produced on a high voltage wave due to the corona load. Others showed the smooth waves, both current and voltage, with kenotron operation, as compared with unsteady current conditions and distorted voltage wave with the mechanical rectifier.

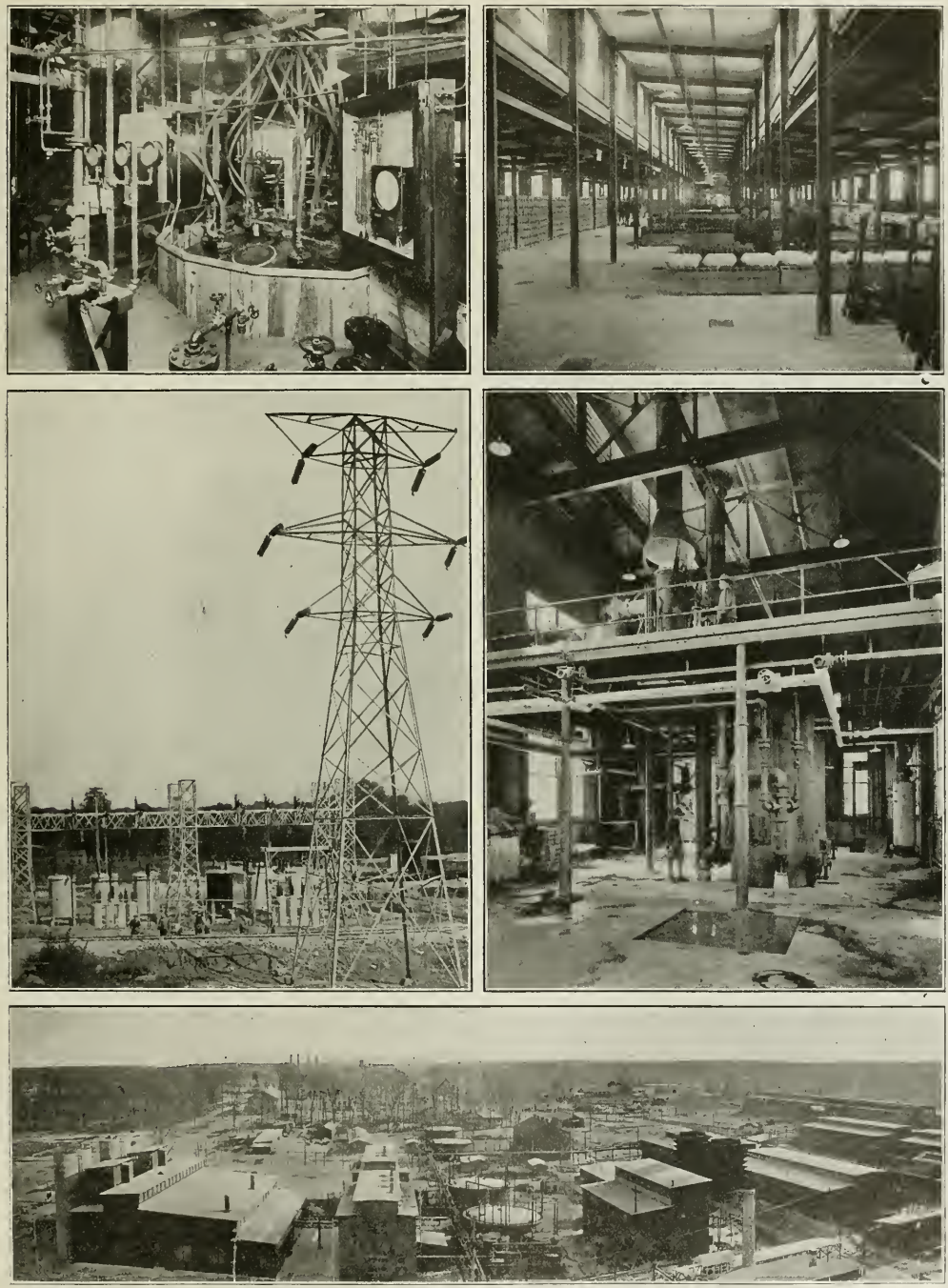
Nelson Chlorine Cell

MR. C. F. CARRIER of the American Cyanamid Co. gave the history and a description of the construction and operation of the Nelson cell. Because of the important part this cell has taken in chlorine production, the full paper will be presented in an early issue.

The illustrated lecture on oxidation of ammonia to nitric acid, by MR. W. S. LANDIS, was largely attended. The paper will be printed in full in a subsequent issue.

Symposium on Released Information

No body of scientists and engineers played a more important part in preparation for war than did the electrochemists. To their lot fell a vast amount of research, construction of tremendous plants and production of important munitions of war. Some of their achievements were disclosed for the first time in the symposium which the Society held on April 4. As one listened to the successive speakers, almost all of whom explained that their work had been interrupted by the armistice, one came to the conclusion that the said armistice was a great bar to scientific progress as well as to the defeat of Germany.



VIEWS OF EDGEWOOD ARSENAL

Upper left—Levinstein mustard gas reactor. Upper right—Shell storage. Center left—Transmission line and transformer station. Center right—CO gas producer. Bottom—General view of phosgene plant.

Col. W. H. Walker gave an illustrated lecture on Edgewood Arsenal, which was a development of the Chemical Warfare Service constructed for the manufacture of poison gases and the filling of shells. He made some introductory remarks on the nature of gas warfare, along the lines set forth in our recently published interview[2] with Brigadier General Amos A. Fries, to wit, that it was not wholly to be condemned and that it had some commendable features. Colonel Walker also expressed the hope that the Chemical Warfare Service would be re-established and maintained as a separate and distinct branch of the military forces.

In the early days of our preparation for gas warfare it was expected that the toxic materials for shell filling would be supplied by manufacturers, but it soon became apparent that this would be inadequate and that a special plant would have to be built. Edgewood Arsenal was the result. Here the Government built and operated a plant of which the country may be proud, both as to technical efficiency and economy of construction. The gases produced by the service were phosgene, chlorpicrin and mustard gas, or dichlordiethylchloride. In the production of the latter our chemists developed a process of treating sulphur chloride with ethylene under proper conditions. This method was far superior to the chlorhydrin process used by the Germans. Colonel Walker spoke enthusiastically of the work of the first enlisted men who worked at the Arsenal, giving them credit for a large share in the general accomplishment. It was his opinion, also, that in no other munition plant was there gathered together so efficient and loyal a body of scientists and engineers.

Smoke Screens

Mr. Otis Hutchins gave an account of the experimental work done in the laboratory of the Carborundum Co. on the production of silicon tetrachloride. A charge of 80 lb. of silicon carbide was packed around a carbon resistor consuming a current of 15 kw. at 15 volts. When heated to the temperature of reaction, chlorine gas was conducted through the mass and silicon tetrachloride obtained by leading the gas through a water-cooled condenser. An average of 20 lb. of $SiCl_4$ was produced per hr. which was limited only by the available chlorine supply. The efficiency of the reaction was from 85 to 90 per cent. About 1500 lb. of $SiCl_4$ was made in all. Silicon tetrachloride was tested out comparatively with the other well-known chlorides of zinc, aluminium, phosphorus, etc., in organic synthesis, but was not found of any special applicability.

Silicon Chloride in the War

Major G. A. Richter gave an excellent account of the method of using silicon chloride in the war as follows:

"The funnel is a smoke device attached to the deck of a vessel and operated to produce a smoke screen as a protection against submarine attacks. It consists of a horizontal cylinder about 6 ft. long and 28 in. in diameter, provided with suitable connections for the introduction of silicon tetrachloride and ammonia under most advantageous conditions. One end of the cylinder is equipped with a hand fan, the function of which is to furnish large volumes of air for dilution of the respective vapors before mixing. The silicon tetrachloride is vaporized through a bank of very efficient spray nozzles located about 12 in. in front of the fan and directed toward the other end of the cylinder. The ammonia is introduced through another spray nozzle located about 12 in. from the exit end of the cylinder and also pointed toward this end of the apparatus.

"The ammonia is forced through the nozzle from a steel cylinder by means of its own vapor pressure. The silicon tetrachloride is propelled from a second steel cylinder by means of dissolved carbon dioxide. The tetrachloride line running from the cylinder to the nozzles is provided with a glass-wool strainer to remove any particles of sediment which may accumulate in the system on standing. To operate this smoke device, both valves leading from the tetrachloride and the ammonia reservoir are opened wide and the hand fan at the rear of the funnel revolved in order to provide sufficient air dilution of the vapors.

"Dry carbon dioxide was selected as a propellant for the silicon tetrachloride for several reasons. It does not react with the tetrachloride at any temperature likely to be encountered. The silicon tetrachloride is forced through the nozzles at nearly a constant pressure and rate, whereas with compressed air or nitrogen the rate of discharge of liquid is seriously affected by the progressive drop in the pressure within the container. Such a change in rate of discharge of silicon tetrachloride causes a variation in the proportion of chemicals delivered and consequently lowers the obscuring power of the smoke produced.

"When the pressure of a solution of carbon dioxide in silicon tetrachloride is released, it effervesces in a way similar to soda water. This behavior apparently causes an exploding effect on the particles of solution discharged through the nozzles, thus resulting in added disintegration and more rapid vaporization.

"Inasmuch as the vapor pressure of liquid ammonia and the total pressure of the silicon tetrachloride solution rise and fall with temperature changes, they tend to keep pace in rates of discharge through the nozzles. Experimentation established an optimum mixture of 12 per cent of carbon dioxide in the silicon tetrachloride. Under a surveillance temperature of 60 deg. C. this composition will generate a pressure of 600 lb. to the square inch. At —26 deg. C. this pressure drops to 225 lb. These experiments were conducted in a vessel two-thirds full of the liquid mixture.

"Every effort is made to duplicate as closely as possible in a practical way those conditions which proved most efficient in the laboratory. A ratio of two parts of tetrachloride to one of ammonia is maintained without much trouble. The liquids are sprayed through the funnel at a rate of 7 lb. and 3½ lb. per minute respectively. A heavy white cloud of high obscuring power is formed. It is easily set up, readily controlled and is so nearly neutral in composition as to allow the vessel generating the smoke to pass through it. A single pair of cylinders contains sufficient material to generate an efficient cloud for a period of thirty minutes."

A Portable Precipitator

Lt.-Col. Arthur B. Lamb gave the details of the miniature Cottrell portable precipitator which he and his research staff, Capts. Gerald L. W. Wendt and Robert E. Wilson, had developed. A lead storage battery in a special form offered the best supply of current so far as weight efficiency was concerned—30 watt-hr. at ½ amp. for 10 hrs. with a weight of 3 lb.

[2] See this journal, Feb. 15, 1919, p. 152.

The best induction coil was a special design furnished by the Samson Electric Co. of Canton, Mass., having an input of 5.8 volts with 0.46 amp., an output of 875 volts with 16 microamp., and an efficiency of 0.52 per cent. The weight of the coils were 14 ounces.

As many tubes as are necessary for the air volume required are used, connected in parallel. In its present form the precipitator uses four glass tubes 1½ cm. in diameter and about 12 cm. long, each wrapped in a strip of copper gauze. In a production form these glass tubes will presumably be replaced by thin tubes of iron or aluminium, glazed or enameled on their inner surface. The inner electrodes are made by cutting a strip of copper-wire cloth of fine mesh in such a way that only two adjacent parallel strands are included, together with the correspondingly short lengths of the many crosswise strands cut. This is then twisted lengthwise through four or five axial turns, and the ends of the long wires are inserted into the heavier electrode holders and insulated from the outer electrode tube.

The weight of the precipitator proper is less than a pound, and when manufactured in quantity need not exceed a few ounces.

EFFECT OF RATE OF FLOW ON PRECIPITATING EFFICIENCY OF SINGLE TUBE

Rate of Flow Liters per Minute	Efficiency Against NH_4Cl Smoke 1 in 10,000
3	100%
5	100%
10	93%
15	85%
25	79%

These results indicated that for a man exercising only moderately, four or perhaps five tubes should afford adequate protection against any toxic smoke. A full-size portable outfit was therefore roughly constructed and tested out in the main testing chamber by wearing it in a cloud of diphenylchlorarsine smoke set up by detonation. Such a test has been found to penetrate all except the very best filters within a few minutes, but the man wearing the electrical precipitator was able to remain for a full hour without suffering any discomfort whatever. This indicated conclusively that the smoke precipitation was complete under these conditions. There was no appreciable resistance to the flow of air through the precipitator. A canister containing gas-mask absorbent was, of course, used between the precipitator and the wearer in order to remove any toxic gas or vapors which might be present. It was found to kill bacteria suspended in the air drawn through it.

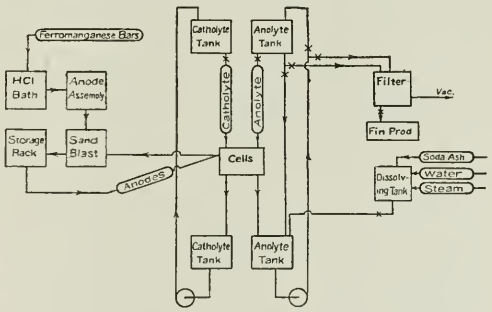
In discussion of Mr. Lamb's paper, MR. MESTON expressed the belief that it would be possible to get the same results with alternating as with direct current—with an induction coil as well as with a storage battery. DR. BANCROFT told of a small Cottrell precipitator which had been made for analyzing smokes, and MR. WILSON referred to the use of the apparatus in hospitals where it had been found much more efficient than the felt gauzes used in contagious diseases. DR. C. A. DOREMUS offered a note on the use of electrostatic precipitation in the manufacture of white arsenic from mispickel, or arsenopyrite. The ore was concentrated and roasted, and the fumes collected in a Cottrell precipitator.

Electrolytic Sodium Permanganate

MESSRS. ROBERT E. WILSON and W. GRENVILLE HORSCH reviewed the development of the ferromanganese electrode sodium permanganate process and gave the following account of the commercial half-ton plant:

"All things considered, the batch system of operation is the one best suited to the electrolytic production of sodium permanganate. Among the chief factors that lead to this conclusion are the simplification resulting from doing the cooling in one place outside of the cells, and the avoidance of the necessity for careful adjustment of the rate of circulation. Furthermore, uniformity of operation is gained by having all the cells throughout the plant operating on electrolyte of the same composition. With the batch system, the process will be intermittent with respect to the product turned out, but continuous in the sense that the current will be kept passing constantly through the cells, which will never be emptied of electrolyte except for purpose of cleaning and of renewal of the diaphragms.

"The interval of time selected for turning out of a single batch is one week. This interval is fixed by the amount of solution placed in the anolyte system and the final concentration of permanganate to be attained in the cells. One week is selected because if the interval is much greater the tankage required becomes excessive. On the other hand, if the interval is much less than one week the 'turn-over' becomes too frequent, resulting in increased labor requirements, and the condition is



FLOW SHEET

approached of having too small a volume of liquor to permit enough being outside the cells for adequate cooling and for settling out of the sludge.

"The concentration of sodium permanganate to be attained in the cells is limited to about 8 per cent, for the reasons previously pointed out. Fortunately, the evaporation of the solution may be carried out easily and inexpensively and if 30 per cent solution is to be produced, as was desired, it makes little difference in the final cost whether the evaporation is started from 8 or from 12 per cent.

"There are four principal operations to be carried out in this process; namely, the preparation of the solution, anode manipulation, filtration, and evaporation. When the plant is started for the first time an 18 per cent caustic soda solution has to be made up. During normal operation, however, there is only the simple preparation of a 12 to 14 per cent solution of soda ash.

"Anode manipulation is a question which demands more attention than it does in the majority of electrolytic processes. It is planned to have the cells arranged in banks of approximately eight each. It will then be possible to handle the anodes from all of the cells in one bank, simultaneously, using a small overhead crane. Thus, after shutting off the current from

the bank, eight anodes together will be raised, reversed, and lowered or carried to the sand-blast room to be cleaned, another set being put in their place. The sand-blasting can be effected while the anodes remain suspended from the trolley which conveyed them to the sand-blast room. The semi-plant scale experiments showed that the anodes would run more than twenty-four hours before needing reversing, and a slightly less time on the second side before removal altogether. It is therefore planned to make operations uniform by reversing the anodes in one-half of the plant each twenty-four hours, and to carry on replacement in the other half during the corresponding interval. This work would not, of course, consume the whole twenty-four hours, but could readily be carried out by two men during an eight-hour shift.

"In this process a sludge consisting of a mixture of the oxides of iron, manganese and silicon is always formed. It is planned to remove most of this by settling in the upper anolyte tank. For the purpose of washing the sludge and filtering the final product vacuum filters are installed.

"The power requirements and arrangement of circuits will be mentioned briefly. All the experiments which have been made are consistent with the belief that the energy consumption will be not greater than 12 kw.-hr. per lb. (26.5 kw.-hr. per kg.) of sodium permanganate produced. Allowing a loss of 3 per cent in evaporation, and, say, 10 per cent due to inactivity of a portion of the plant, a producing capacity in the cells of 1130 lb. (514 kg.) per 24 hr. must be allowed in order to turn out 1000 lb. (453 kg.) of the finished product. The power required is therefore found to be about 570 kw. It is planned to generate this power at about 112 volts. The cells will be connected in series-parallel, with a third wire running between in such a way that a single bank of eight cells may be cut out with very little disturbing effect on the current passing through the remaining cells. Running at a current density of 120 amp. per sq.ft., each cell exhibits a resultant drop in potential of about 7 volts.

"A design has been made and submitted to the Government giving rather detailed plans and specifications for a half-ton plant and including an estimate of the cost based on the best information in the light of all the work done. This estimate assumes the cost of raw materials, labor, and construction to be as they were in the year 1918, and provides for writing off the plant in two years.

"Based on these war-time conditions a fairly accurate cost of building and equipment (not including a substation, since the power cost estimate is based on 110-volt D. C., delivered to the plant) for such a plant is $85,000. Pure sodium permanganate in 30 per cent solution could be produced for about 60c. per lb. This cost can be further analyzed as follows:

Raw materials	$0.183
Power at $30 per hp.-yr	.067
Amortization	.120
Labor and overhead	.090
Contingencies	.140

Electric Furnace Manufacture of Silico-manganese

This paper dealt with war-time production of silico-manganese at Anniston, Ala., by the author, MR. B. G. KLUGH. The work was done in rectangular open-top furnaces comprising a steel shell 15 ft. by 7.5 ft. by 5 ft. high in one case, and 18 ft. by 9 ft. by 5 ft. high in another. The furnaces were 3-phase with 3 electrodes in line. Current was furnished at 22,000 volts and stepped down to 65 for the small and 100 for the large furnace. The raw materials used were silica rock, manganese ore, limestone and bituminous coal. The analysis of a 50-ton lot was Mn, 65 per cent; Si, 21; Fe, 13; C, less than 1. The following data relate to this product:

Ratio of ore to metal	3.53
Mn charged in metal, per cent	73.00
Mn charged in slag, per cent	10.02
Mn charged in gas (by diff.), per cent	16.98
Total weight of charge in metal, per cent	16.11
Total weight of charge in slag, per cent	31.34
Total weight of charge in gas, per cent	52.55
Pounds slag per ton of metal	4,358
Pounds gas per ton of metal	7,308
Pounds electrode per ton of metal	168
Pounds reducing carbon per ton of metal	1,715
Kw.-hr. per ton of metal	9,000

The author realizes that these results are not ideally economic, but presents them as showing what was accomplished under war-time conditions. In 1918, due to the shortage of manganese ores, the company made use of high-manganese slags from former operations, also from blast-furnace operations. One hundred tons of metal produced averaged Mn, 70 per cent; Fe, 9; Si, 20; C, less than 1. The treated slag and that resulting from the smelting had the following percentage compositions:

	Mn	SiO_2	Al_2O_3	CaO	MgO	BaO
Slag treated	20	34	14	25	2.0	1.5
Slag produced	1	29	23	42	2.7	1.6

Current consumption was 15,000 kw.-hr. per ton of metal. Mr. Klugh states that no difficulty is experienced in producing alloys of specified composition, within the limits of analytical error, and believes that if steel makers desired a certain SiMn alloy it could easily be furnished and replace the use of ferromanganese and ferrosilicon.

Lead Plating

MR. A. G. REEVE gave an interesting account of leading gas shells. Shells, copper "struck," filled with lead bath, anode and paddle, were placed on the plating bench (fifty-two 75 mm., 4.7 in. or 155 mm. shells per bench unit), anode and paddle quickly attached to the rotating spindles, and deposition begun.

Each spindle could be raised and disengaged from the driving pulley independently. The entire frame carrying the 52 spindles could be readily raised or lowered to suit the various shell sizes.

Current was supplied to the spindle through its two babbitt bearings set in woodwork. To use the available ampere-hours advantageously, the 52 spindles were divided into four batteries and connected in series, with 6-volt plating current, the 13 spindles of each battery being connected in multiple. To insure uniformity each shell was given a new anode, the old ones being re-cast.

The specification for gas shells required that the thickness of plating should not be less than ten nor more than fourteen thousandths inch (0.25-0.35 mm.) for all sizes, except that five thousandths (0.125 mm.) was desired on the threads in the opening. This was accomplished by withdrawing from the shell, when half plated, a small portion of the bath by use of a rubber bulb and a brass tube bent at the end so as to reach down only the required distance into the shell opening. To further equalize the thickness of deposit, each shell was turned part way around on its axis several times during the plating period.

The following table gives approximate data on the

volumes, areas, amperes, and time, etc., for three shell sizes:

	Exposed Anode Surface, Sq.In.	Cathode Surface Sq.In.	Ounces Lead Deposited	Amperes	Hours
75 mm.....	11.50 (18 sq.cm.)	64 (100 sq.cm.)	4.51 (127 g.)	5	6.63
4.7 inch.....	20.07 (31 sq.cm.)	147 (229 sq.cm.)	10.21 (289 g.)	10	7.50
155 mm.....	37.06 (58 sq.cm.)	266 (412 sq.cm.)	18.61 (529 g.)	20	6.84

The bath as received from the refiners ready for use analyzed about as follows:

Deg. Baumé	Per Cent Pb	Per Cent H_2SiF_6	Per Cent Free H_2SiF_6	Per Cent Glue
43	18.02	14.14	2.90	0.4

This was supposed to work best at 95 deg. to 100 deg. F. (35-38 deg. C.) with from 2 to 5 per cent free acid, and in practice it was found that the resistance of the bath was such that with 6 volts the shells and bath soon warmed up to the desired temperature while the plating was going on.

Regardless of the recommendations of those who furnished the lead bath, the quality of the deposit was materially improved by the addition of 2 lb. of glue to each barrel (50 gal.) (5 g. per liter) of new bath before using. As fast as the plating operation was completed the bath was poured out of the shells and filtered, and one lb. of glue added per barrel of bath (2.5 g. per liter) each time it plated a set-up of shells. The number of shells set up for plating with one barrel of bath and the volume of lead deposited per barrel set up, are given below:

	75 mm.	4.7 in.	155 mm.
No. of shells filled per barrel (190 liters) of bath...	346.0	100	42.37
Lb. of lead deposited per barrel (190 liters) of bath.	97.3 (44.2 kg.)	64 (29.1 kg.)	49.30 (22.4 kg.)

It will thus be noted that in the 75-mm. shells each gallon of bath deposited nearly 2 bbl. of lead in 6.63 hr., with one glue addition. The discoloration which the exterior of the shells acquired was scoured off by a revolving brush with an abrasive and water.

Mr. Blum called attention to the extension of lead plating, saying that before the war there were but two or three places in the United States where it was done, and that within two months after war was on there were from 20 to 25 plants in existence. He believed that lead plating was likely to find new applications in industry because there was no difficulty in depositing coatings up to $\frac{1}{16}$ in. in thickness. In lining some catalyzers for the Edgewood Arsenal the Bureau of Standards had treated an area of over 50 sq.ft. and had deposited 275 lb. of lead.

Mr. E. C. Walker said that he had eliminated the difficulty of plating the bottom of the booster orifice by circulating the electrolyte and using still anodes, whereas the author of the paper had used rotating anodes.

Mr. Frary referred to Mr. Blum's work at the Arsenal and said that before satisfactory work finally was done there had been trouble with blistering in the lead coating itself. It was finally proved that the trouble was in the preliminary pickling of the vessel, and that when the surface was prepared by sand-blasting instead of pickling the trouble vanished.

Mr. Bradley asked if the process could be applied to the lead-lining of pipes for resistance against attack of sulphuric acid. Mr. Reeve thought this could be accomplished without difficulty; and Mr. Walker mentioned the successful coating of pipes and buckets. The latter were used for carrying sulphuric acid, and had a coating 0.001 in. thick.

Mr. T. P. Baily gave a paper on the heat treatment of anchor chain, drawbar knuckles and aëroplane parts, and the melting of yellow brass, which was excellently illustrated with moving pictures. The heating is accomplished by an electrical resistor of granular carbon contained in carborundum fire-sand beds. The apparatus is controlled by pyrometers which maintain exactly the desired heats. Chains of 90 ft. length and 3400 lb. weight were treated at the National Malleable Castings Co. for the Emergency Fleet Corporation.

Mr. George K. Elliott described the experience of the Lunkenheimer Co. with duplex process iron castings. The molten iron tapped from the cupola was superheated in a basic electric resistance furnace. Improved fluidity was obtained due to the higher temperatures obtainable and, most important of all, the sulphur content was decreased from 0.1 per cent to 0.03 per cent in 25 minutes. The process presents an important field for future development where better strengths are required than can be obtained from ordinary cupola iron. Steel castings can readily be made, as there is no limitation to the heats obtained for fusions.

Mr. W. E. Moore discussed electric steel made in acid furnaces. He concluded that electric steel is superior to the product of the small ovenhearth or the converter in regard to costs of raw materials, alloys, refractories and composition control.

Mr. C. S. Cox of the Duquesne Light Co., Pittsburgh, read a paper on "Power Production for Electrochemical Purposes." He stated that steam-generated electricity can compete with hydraulic in all cases except where great natural advantages are found.

Resumption of Trade With Certain Countries

The War Trade Board has from time to time, since the armistice, announced the resumption of trade with certain countries in Europe with which trade was prohibited during the war by reason of the blockade.

In order that the business public may now have a complete list of these countries, the Board announces (W. T. B. R. 687) that trade has been resumed with Siberia (see W. T. B. R. 470, issued Jan. 3, 1919). Alsace-Lorraine (see W. T. B. R. 486, issued Jan. 8, 1919), Palestine and Syria (see W. T. B. R. 530, issued Jan. 20, 1919), Mesopotamia (see W. T. B. R. 560, issued Feb. 3, 1919), Servia and Roumania (see W. T. B. R. 551, issued Feb. 4, 1919), the territory included in the line set out in article 3 of the military clause of the armistice protocol of Nov. 3, 1918 (see W. T. B. R. 574, issued Feb. 4, 1919), Finland (see W. T. B. R. 590, issued Feb. 11, 1919), Czecho-Slovakia (see W. T. B. R. 594, issued Feb. 13, 1919), Bulgaria, Turkey, and Black Sea ports (see W. T. B. R. 602, issued Feb. 16, 1919, and W. T. B. R. 665, issued Mar. 24, 1919), German colonies (see W. T. B. R. 609, issued Feb. 21, 1919), the occupied territory of Germany (see W. T. B. R. 610, issued Feb. 22, 1919), Adriatic ports, Albania, and Montenegro (see W. T. B. R. 623, issued Feb. 28, 1919), Luxemburg (see W. T. B. R. 652, issued Mar. 17, 1919), the territory adjacent to and dependent upon the Adriatic ports, including Albania, Montenegro, Croatia, Slavonia, Bosnia, Herzegovina, and Dalmatia (see W. T. B. R. 656, issued Mar. 20, 1919), Poland (see W. T. B. R. 675, issued Apr. 1, 1919), Esthonia (see W. T. B. R. 676, issued Apr. 1, 1919), and German-Austria (see W. T. B. R. 679, issued Apr. 2, 1919).

Aluminum Co. of America | Hydraulic Power Co. | Cliff Paper Co. | W. A. Roger Silverware Co. | City of Niagara Falls | Niagara Park

Buffalo Meeting of the American Chemical Society

Report of Acts of Council and Technical Sessions—Best Attended Meeting in the History of the Society—Sessions Enlivened by Successful Smoker and Banquet—Symposiums on Library Service and Mustard Gas

THE 57th meeting of the American Chemical Society at Buffalo was called "Victory Meeting," and it was very largely attended.

Meeting of the Council

The Council was called to order at the University Club at 4 p.m. on Monday, April 7, there being ninety-two Councilors present, the largest number that ever has been counted at one meeting. Aside from routine business, provision was made for specifications for standard laboratory apparatus and for specifications for a standard polariscope. The German instrument which was formerly used by sugar chemists differs from the French type, and presents some undesirable irregularities. A committee is to devise and recommend specifications.

It was agreed to urge as a basis for governmental action the appointment of a high commission to coordinate the natural resources of the country, and it was recommended that in the proposed international councils of chemistry both pure and applied science be included as component parts of it, rather than that their spheres of activity be divided. It was also urged that neutral nations be invited immediately to participate in the deliberations of the body, and to be represented in its membership. A division of Rubber Chemistry has been added to the Society, and it was announced that a Dyestuff Section, of which Dr. C. L. Reese is chairman and R. Norris Shreve secretary, will function at the September meeting in Philadelphia. Reports of many committees were read.

It was decided that all papers presented at any meeting of any section are properly available for publication in the Society's journals and may only be released under permission of its editors.

During recess, at the invitation of the Western N. Y. Section of the Society, the Council dined at the University Club, and immediately afterward resumed its session.

Discussions of Reports

The evening was devoted to discussions of reports, among which was one on Co-operation Between Industries and Universities, and one on Compendia of Chemical Literature and that of the Clearing Committee. The report on Compendia, presented by Dr. Stieglitz, proposed that American chemists take up the preparation of critical volumes on physical and chemical constants and related numerical data (besides certain monographs in other fields as specified). This will leave to the British Commission the preparation of compendia of inorganic and organic chemistry, and to the French Secretariat of the International Commission on Annual Tables of Constants, etc., the continued compilation of non-critical abstracts of constants, numerical data, etc. Convincing reasons for this subdivision of the work were given. The business control of the publication it is proposed to vest in these trustees.

It was in December last that President Nichols called a meeting of the Council to consider proposals in relation to reconstruction. The proposals were at once so multitudinous and miscellaneous that they were referred to an omnibus or clearance committee of which Dr. Arthur D. Little was chairman. The committee laid away in cold storage a large number of recommendations that were evidently designed for other worlds than this, and proceeded to work out into definite shape and form, those that might, could, would or should be undertaken. The whole series offered enough opportunities to appease the most insatiate workers, with

American Falls | Goat Island | Horseshoe Falls | Niagara Falls Power Co. | Victoria Park

enough left over to last, as somebody said, about a hundred years. It is to be printed and circulated for discussion later.

The General Meeting

On Tuesday morning, April 8, the general meeting was held in the ballroom of the Hotel Statler at 9.30 o'clock. There was standing room only, and not much of that. The reason for this was due to the habit of members of the Society to refrain from advising the secretary whether they intend to be present or not, and then coming in great numbers. Out of a total registration of 1150 only 150 had signified to the secretary their intention to be present. The contribution of CHEMICAL & METALLURGICAL ENGINEERING of a printed registration list in convenient form which appeared every afternoon seemed to find favor. It gave the name and address in Buffalo of every registrant.

The HON. GEORGE F. BECK, Mayor of Buffalo, made a short speech of welcome in which, possibly instigated by the threatening rain, he expressed regret that the Society had chosen a season for its visit when the climate of the city was less attractive than at other times. Those who are familiar with the cold blasts of Lake Erie in the Fall and Winter were content to be present in the Spring. He cited statistics relating to the city among which was contained the information that in 1828 one-third of the traffic of the Erie Canal was taken up with the transport of whiskey.

DR. NICHOLS responded in his usual happy manner, after which, in a business meeting that followed, PROFESSOR GIACOMO CIAMISIAN of Bologna, Italy, was elected an honorary member.

DR. (LIEUTENANT-COLONEL) WILDER D. BANCROFT, who is the first of the annual chairmen of the Chemical Section of the National Research Council, reported that that body will now continue its activities on a peace basis. He announced that the Rockefeller Foundation had set aside $500,000 to be spent within the next five years for fellowships in research in chemistry and physics. The minimum fellowship is to be $1500 annually, and it is intended to make these the equivalent of post-doctorate fellowships, although it is not demanded of aspirants that they have Ph.D., or Sc.D. degrees. There are no strings whatever attached to the offer. Anybody who has research in hand or under consideration may apply. He may choose his own subject and his own institution of learning, subject, of course, to the approval of the committee which has the matter in charge. It is hoped to continue good men in research on some problems for terms of two or three years, so that work may be brought as nearly as possible to completion. The committee is ready now to consider applications. It is really an extraordinary opportunity. All that is required is qualification in scholarship and ability, and merit in the subject. Applicants should address Dr. Wilder D. Bancroft, Chairman Division of Chemistry, National Research Council, Washington, D. C.

The President made an appeal on behalf of the children of French chemists and engineers who, as officers, have fallen in the war. This supplemented a similar appeal from Secretary Parsons at the meeting of the Council.

President Nichols' Address

PRESIDENT NICHOLS then made a short address on reconstruction. He declared that the way in which reconstruction problems are solved will be of vast influence, either for good or for evil, for the next century. Without doubt peace terms will soon be agreed upon, and we then should prepare ourselves for peace. Until lately public and private interests have been subordinated to winning the war. In making the change we must bear the public welfare in mind, and remember that we cannot possibly return to the conditions of five years ago. Awful damage has been done, and things cannot be made the same as they were. Revolution has been in process for some time, and revolution can be just as effective, even if we see but little of it on the surface, as if it were to march with plumes and banners. Great changes have taken place, among which we must count the enormous additions to public debts which are said at present to exceed $315,000,000,000. Now the honest thing to do with debts is to pay them, and reconstruction must look forward to eventual liquidation.

SHOULD SEEK PATH OF WISDOM ON LABOR QUESTION

Many employers have been disposed to regard their employees merely as so many hands. Now the pendulum is swinging the other way, and labor is at times disposed

to hold that leadership and the administration of industrial affairs rest solely within its councils. It is our business to seek the path of wisdom, and not alone to find it, but to demonstrate that only by the earnest co-operation of labor and capital, working in harmony and not at cross-purposes, can industry endure. We must bear in mind that quality of product, efficiency of work, and right living under wholesome conditions, are important things, and that wages are subsidiary to them.

Another silent revolution has been the change in the character of our population within the last fifty years. Many of our new citizens have brought with them old-world theories of the inviolability of force.

Prohibition, which we awoke one morning to find all inscribed upon the Constitution, is not a subject the merits of which we should discuss at this place. But we must beware lest so important a material as ethyl alcohol be legislated out of industry as well as out of drink.

The conservation of our national resources, including water power, forest products, and many other sources of wealth, is a very pressing question. Dr. Nichols urged all present to read an article in the March number of the *Atlantic Monthly*, by Dr. Arthur D. Little, entitled "Developing the Estate," to learn of our wasteful extravagance, and of what we should do to prevent it. He expressed the opinion that our great stores of sulphur should not be used where pyrites and sulphurous ores could be roasted to provide what is needed, and he believed that the great opportunities for chemists is to be found along the lines of conservation.

In regard to unrest among workers he pointed out that many employers have been guilty of unfairness. There has probably been less of this than many suppose to be the case, and the condition of the worker has been constantly improving for as long a time as he could remember. Nevertheless the unrest continues. Now, if the present system results in continuous improvement, it is a fair question to ask why it should be changed, as many demand, for something which, as evidence shows, produces nothing but sorrow and destruction. He believed that the only affirmative answer to this is to be found in the propaganda of men and women who can make an easier living by talking than by working. During the reconstruction period we must demonstrate conclusively that our present civilization is based on justice and equity for all. By this means we can set at naught the eloquence of the professional agitator.

Tariff Commissioner Culbertson

The Hon. William S. Culbertson of the U. S. Tariff Commission spoke on "American Chemical Industries and the Tariff Commission." The two outstanding forces which modified chemical industry during the war were the isolation of the Central Powers and war orders. The American public realizes now as it never did before the relation of chemical industries to the national welfare. The month of famine in dyes was the most potent argument it ever encountered in support of this thesis. There were other problems, however, which had to be met, and which were met, but were, of course, less spectacular. Among these were chlorine and chlorine products, barium salts, caustic soda and many others. The speaker thought that the importation of monazite sands from Brazil to make thorium nitrate, in Germany, and the following exportation to this country as gas mantles or preparations for mantles, was one of the most illuminating examples of how not to conduct an industry—so far as America was concerned. And the speedy development of the rare earth industry in this country under pressure of need he regarded as even more illuminating—as showing how things should be done.

The same conditions that obtained in this country operated also in Great Britain, Norway, Sweden and Japan. They have been busy to capacity, supplying war needs until lately; and now they must look for other markets. Investigation of commercial policies is greatly needed, as well as an assemblage of facts related to them.

The war solved some problems in chemical industry, and it created others. It also taught us certain things, among which we may mention for example, the fact that a policy of *laissez faire* has no place in chemical industry.

In the mind of the speaker there is no question that the coal-tar dye industry needs protection. As soon as hostilities ceased Great Britain took steps to conserve her own dye industry by prohibiting all imports of dyes, except such as are authorized by a licensing board, Mr. Culbertson felt that we cannot adopt such a measure, and that we must find our safeguard in the tariff. Our industry is doing business on a lively scale, but it cannot be expected to be able to accomplish in four years what the Germans did in forty to fifty years. The Germans have the advantage of priority in the art, and they have always taken advantage of unfair practices. The difference in priority Mr. Culbertson believed could be met by the tariff, and such unfair practices as bribery and full-line-forcing by the Bureau of Foreign and Domestic Commerce. But dumping surplus stocks at less than cost to gain a market is another problem, and in order to meet this Mr. Culbertson proposes that the tariff law be supplemented, giving the President extraordinary powers to prohibit importations and to increase duties on all materials which he has reason to believe would be sold with a view to destroying competition.

Mr. Joseph H. Choate, Jr., on the Chemical Foundation

Mr. Joseph H. Choate, Jr., general counsel to the Chemical Foundation, spoke on "German Methods and Our Present Situation." He said that the efforts of the Alien Property Custodian had centered in the beginning on the dye industry, so far as chemicals were concerned, and that pharmaceuticals followed. Heavy chemicals in the U. S. seemed to be generally free from German ownership.

In regard to dyes the Germans held in substance a world monopoly, acquired by a combination of natural advantages, and sub-natural methods. They had cheap and docile labor and cheap chemists. They could combine into any kind of a tangle they desired, and the more they interlocked the better the government liked it. First they made two great trusts, and in time the twain became one. Manufacturing on a large scale brought down production costs, which gave a large surplus for export, and the government liked this too. The big trust was formed avowedly for foreign trade, and it has available capital of about half a billion dollars. It is a mighty power.

In the United States they found the dye business permeated with Germans and German chemists, but there was hardly a sign of German ownership, except

among three concerns which reported German ownership. This amazing manifestation of German integrity almost stunned them at first, but, after diligent search, an example of its working was discovered, in the Bayer Co. This concern had an enormous fund from goods sold in the East which could not be remitted to Germany. Among the many uses to which this fund was put was the secret purchase of a nice little going concern known as the Williams & Crowell Co., to which all the assets were being quietly transferred, so that when the Alien Property Custodian should take over the German-owned agency, he might receive an empty shell. When he included the Williams & Crowell Co. in his seizure there ascended unto the skies a high and mighty wail. Hoechst, Cassella and the Badische claimed to be owned by Americans, and the speaker believed that a great hazard to American industry was averted when the actual participation of the German trust in these concerns was smoked out. The Badische interests, for instance, were shown to have belonged always, from the very beginning, to American agents in New York. There was no record anywhere that the German company had been interested. But the remittance of $1,250,000 as dividends by the American agents to the Badische Co. within a rather short period of time was sufficient evidence to convince Mr. Palmer that the Badische Co., after all, was interested. The Hayden Chemical Co. and the Bauer Chemical Co. transferred their stocks in February, 1917, to their general counsels, but the purchasers did not pay for them. German ownership has been pretty well brought to light, he believes.

How Best to Protect American Industry

But there remains the great trust. What has it been doing during the years of the war? Of course we don't know, and without doubt some of its branches have been making munitions. It is fair to believe, however, that vast quantities of cotton vat and other much-desired dyes are stored up, ready to be thrown upon the market here at any price. Mr. Choate did not see how a tariff alone can protect the American dye industry. The German trust can afford to buck up against a 100 per cent tariff, and finally control the situation. He believed the industry in this country to be in a precarious condition, and said that in considering the matter the Alien Property Custodian had come to the conclusion that the only way to stave off a recurrence of the German monopoly was by seizing their patents and preventing control from that source. The Chemical Foundation was therefore formed which purchased in fee all German chemical patents from the U. S. Government, for $250,000. As an organization designed to benefit chemical industry in the U. S. it is hoped that as time goes on the Foundation may buy other patents and continue indefinitely to sell rights under them. But all of these measures will not suffice, in the views of the speaker, to conserve the industry against an antagonist so strong and unprincipled as the German syndicate, unless our Government follows the lead of our British cousins by taking the bull by the horns, and prohibiting imports of dyes, save under a specific license in each individual case.

This was followed by a very pretty little tilt at argument in which Mr. Choate favored the license system and Mr. Culbertson opposed it, in the belief that a proper tariff provision would be an adequate protection for the United States.

Mustard Gas Symposium

On Tuesday afternoon there was held a symposium on Mustard Gas, in the auditorium of the Technical High School. It covered the ground so thoroughly that it became necessary to continue the discussion over to Wednesday morning, drawing a large attendance. Space forbids our reporting the papers in detail, but we cannot suppress the wish that the entire proceedings might be recorded in a separate volume. Despite what appears to be the conclusion of certain governmental authorities to break up the Chemical Warfare Service by extracting the chemistry from it, separating defense from offense, destroying the works, and vesting whatever authority may remain in men with neither training nor experience nor interest in chemical warfare, we know that chemical warfare is here to stay. To the nation at war that is not prepared against it it assures certain defeat, while to the army that is prepared, it is the least dangerous and most humane of all methods of attack. In the interest of the general welfare the chemists of the country should preserve as much as they can from the official discard.

Divisional Meetings

On the morning of Wednesday, April 9, the Divisional Meetings began, and the most important paper of the whole convention was then presented by Dr. Irving Langmuir of the General Electric Laboratories, before the Division of Physical and Inorganic Chemistry, on "The Arrangement of Electrons in Atoms and Molecules." A well-known chemist declared the occasion to vie in importance with the first presentation by John Dalton of his atomic theory. Dr. Langmuir spoke for an hour and a half, before an audience that crowded nearly every square foot of space, and he spoke as one inspired. Later numbers of the journal of the Society will print his exhaustive presentation of the subject, but we are sure that all his hearers will remember the occasion. He started with the theory of "The Atom and the Molecule" as presented by G. N. Lewis, and followed it as far as it went. Then, by a series of postulates, which we shall not repeat because they would require explanatory comment to bring them into correlation, he arrives at a structural theory of the atom which becomes a complete working hypothesis, explaining valence, the irregularities of the periodic law, compounds of the CO type, and the theory of Werner. So profound was the impression made by this masterly presentation, that by urgent request it was repeated on Thursday morning before the Division of Industrial Chemists and Chemical Engineers in the auditorium of the Technical High School.

Preferential Catalyses in the Purification of Hydrogen

Professor H. S. Taylor of Princeton followed with a short talk on "Preferential Catalyses in the Purification of Hydrogen" which contained an interesting statement, and a suggestion that is well worthy the attention of industrial chemists. He desired to oxidize CO, contained as an impurity, to CO_2. With Ni he oxidized hydrogen also, to water, but FeO_3 he found to be selective. Trouble was the process was slow. By mixing two catalytic agents in the proportion of 85 to 15, viz.: FeO_3 and Cr_2O_3 the reaction was speeded up 700 times. Professor Taylor urged further research along the lines of these catalytic boosters, in the interest of better chemical control in technology.

In the Division of Industrial Chemists and Chemical Engineers the proceedings began with a series of twelve papers on Library Service in Industrial Laboratories. The contributions were from librarians engaged with the Carnegie Library of Pittsburgh, Dr. George W. Crile, Eastman Kodak Co., the Chemical Catalog Co., Arthur D. Little, Inc., National Aniline & Chemical Co., Inc., National Carbon Co., N. J. inc Co., Stone & Webster, the Solvay Process Co., The Barrett Co., and E. I. du Pont de Nemours & Co.

Uses for Libraries

Limitations of space again forbid details, but possibly the following argument may roughly cover the ground. If men are to work with their minds with a view to making needed things as well as possible, and as cheap as possible, it is part of the game to let them learn what others have accomplished along similar lines. The information is contained in periodicals and books. These are valueless unless they are available, and they are not available unless each is to be found in a particular place on a particular shelf. When this situation has been reached a library results. Now library service consists in telling the man who wants to know in which book or paper he can find the information he is seeking, and where to look for these. Titles often are misleading.

Other Papers

Dr. Adams T. Clarke told of the joys and sorrows of producing unusual organic compounds for chemical research, and expressed his obligations to many manufacturers for their assistance. Dr. W. J. Hale of the Dow Chemical Co. followed with the opinion that manufacturers should do more; that they should send their products freely, and that they should purify the materials themselves, as far as possible, which is often a much cheaper process for the original maker than for Dr. Clarke in his establishment. He wanted to see the prices for pure chemicals brought down.

Dr. A. G. Peterkin presented a paper on phenol, in which he reported 8,000,000 lb. as the annual pre-war consumption in the U. S. This was chiefly imported from England. During the war manufacture increased to the rate of 150,000,000 lb. annually, of which not over 2,000,000 lb. was distilled direct from coal tar. The Government now has from 30 to 50 million lb. on hand, and uses for it are wanted. When present stocks are absorbed there should be use for the output of one or two phenol plants in this country.

Dr. Paul Rudnick gave a series of tests of metals held in couples in solutions of $CaCl_2$, which are offered for sale as motor car anti-freezing mixtures. In many cases the metals held up well for eighteen days, but lost in weight seriously the ensuing week. His conclusions were not favorable to the use of $CaCl_2$ in automobile anti-freezing mixtures, and this was confirmed by a majority of those who followed him in discussion. One member had reached like conclusions, and had advised against such a mixture, but his advice was disregarded, and after two winters the old machines were still in running order. Against this, however, many machines were reported as seriously damaged after short use of such mixtures. Aluminium suffers most from them.

Three Papers by Dr. Baskerville

Dr. Charles Baskerville presented three papers. The first was on lead-coated iron sheets which were free from pin-holes. A roof made of this material has been exposed to the weather since 1914, and is still good. The second was a reinforced lead, of which he showed examples in sheets, similar to wire glass in its reinforcement. Seven-inch vacuum mains made of this material showed no tendency to collapse. The third paper had to do with "Utilization of Asphaltic Base Acid Sludge from Petroleum." The sludge is treated in the following manner: After heating to about 120 deg. F., the sludge separates into three layers, of which the bottom is concentrated acid, and is recovered. The middle zone contains the asphaltic bodies, which are washed with water, and treated with lime. A useful asphalt paper was shown, made of this recovered material.

Mr. R. O. E. Davis gave results of his work, showing difficulties in connection with CO in the Bucher process. The effects were found due to the small amount of CO_2 that is always in equilibrium. Eight-tenths of one per

cent of CO_2 totally inhibits the yield of fixed nitrogen. Four-tenths of one per cent permits a yield of 60 per cent, and the presence of one-tenth of 1 per cent or less has no effect. One of the mysteries still to be solved in the Bucher process is to determine what the product really is. It is neither a cyanide nor a cyanamide, but rather a mixture of several nitro carbides which have not yet been isolated and determined.

Social Features

The smoker on Tuesday night was about the liveliest entertainment of the kind we have ever attended. The chairman of the committee, Mr. F. A. Lidbury, is not given to inertia in the presence of opportunities to crack heads, and on such occasions he is no milder than a man from Kildare with a blackthorn. Nobody was safe after his name was called.

On Wednesday evening at 6 o'clock the members of the Council were entertained at dinner by one of their number, the Rev. M. J. Ahern, S. J., President of Canisius College, in the refectory of that institution.

At 8.30 on the same evening Provost Edgar F. Smith of the University of Pennsylvania delivered a very scholarly address to a large body of members and guests of the Society and Buffalo citizens in the auditorium of the Hutchinson High School, on "A Chemical Story." He brought out how the phlogiston theory met its original defeat in Philadelphia, at the hands of young James Woodhouse in argument with Joseph Priestly. He also gave a remarkable list of American origins in chemistry and physics that have been forgotten in the literature, and he made an earnest plea for their incorporation in text-books. Why American scholarship seemed to pass under a cloud in the first half of the nineteenth century and to forget even its own, is an interesting question which the good Dr. Smith did not undertake to answer—and this is no place to discuss it.

On Thursday evening the banquet was held, at which Mr. Lidbury presided as toastmaster. In this post he was almost as gentle as a dove—and yet not quite as gentle as a dove. There were many speeches, but none of them long. The toastmaster had a stop-watch and a bell.

Seeing Chemical Plant Apparatus Made

THE addresses and papers of the Spring meeting of the American Chemical Society at Buffalo were followed by exceptionally interesting plant visits. That to the Schoellkopf works of the National Aniline & Chemical Co. should prove an inspiration to the 1100 members in attendance. Though they could have stayed home and perhaps ultimately read in their publications the hundred-odd papers given at the sessions, they never could have received the personal enthusiasm for American chemistry that would have resulted from seeing and then believing in our own industrial efforts.

After being informed that the annual production of dyes in the Schoellkopf plant had been pushed from 2,000,000 to 22,000,000 lb. during the war; the rapid and partial inspection of the works through huge boiler, power and refrigeration plants, and by batteries of mixing machines, autoclaves, filter presses, tanks, stills and condensers, all as compact as extensive, can convey no more than a general impression of the great quantities and types of apparatus used there.

The plant of the Buffalo Foundry & Machine Co. was of especial interest to the industrial chemists on the tour, for here is made Buflokast and Buflovak chemical apparatus. Believing that the attendance represented but a very small part of those keenly interested in seeing chemical apparatus made, we take this opportunity to carry a few views and notes to our readers, in the hope that they will find them of value.

Melting Iron for Casting

Two types of cupolas are used in this foundry. The air furnace is reverberatory and has the advantage that the molten metal does not come into contact with the fuel impurities such as pyrite sulphur. Eight hundred thousand cubic feet of air (64,800 lb.) is used in this furnace per hour, consuming about seven tons of coke and producing 27 tons of molten iron. Since the heat generated by a pound of coke should theoretically melt about 40 lb. of iron, assuming that the combustion and absorption be perfect, it will be seen that an ideal efficiency of only 10 per cent of the heat energy is

SWEEPING FUSION POT CORES

obtainable. Fluorspar is used as a flux in some cases, and white marble chips in others. A tuyere area equal to 31 pipes of 6-in. diameter is required. Ten inches clearance is allowed between them and the sand floor of the cupola. The other cupolas are of the standard foundry type and have a 15- and 10-ton capacity per hour each.

Making Cores

The characteristic of almost all chemical castings is that they require unusually large cores. Containers holding as much as 400 cu.ft. are ordinary. Both the design and size of the cavity in the casting is obtained by properly suspending and submerging the core. The latter operations are by no means simple. The buoyancy effect of the molten iron, which is about three times heavier than the core material per unit volume, has to be overcome by large iron weights, more than twice as heavy as the submerged core.

The illustration of the fusion pot cores shows the materials and method used in building cores. The center is built up of brick and mortar reinforced with iron rods and ties. Over this a refractory loam is applied and shaped by a revolving sweep, having the center of the core as axis. When the design is finished, the core, which has been built on a car, is run into a drying kiln and fired to remove all moisture. This is very important because water will not only chill the iron too rapidly but gases excessively—expanding about 9000 times in volume. Upon taking the core from the dry kiln, small drying checks are finished over with a special preparation, which imparts a smooth and very refractory finish.

DISSOLVING TANK MOLD

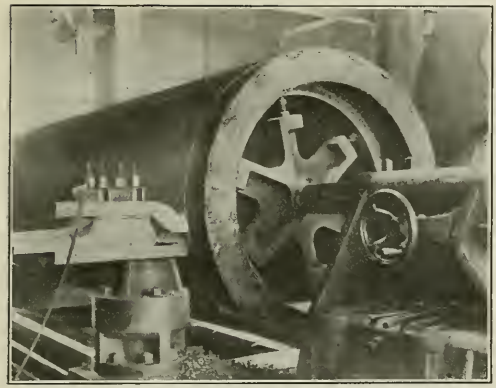
Sweeping Molds

Patterns, sweeps and shaping tools with the skill of the molder are all in need. The illustration shows the mold for a 14-ft. 4-in. dissolving tank in preparation. The sweep for shaping the cylindrical walls and the pattern shaped ribs in the bottom can be seen. The depth of this casting is about 9 ft. As molten iron has a fluid pressure about seven times as great as water, the need for deep pit casting is evident. The ground is well vented with cinder bedding and pipes. The walls of the finished mold are torch baked and finished off similarly to the core surfaces.

POURING A HIGH RISER CASTING

Pouring Castings

After the core has been properly centered and weighted, the ladle is filled with the required amount of metal. The channel for the inflow is connected with the base of the mold and in this way a minimum amount of abrasion of the earth walls is obtained during the pour. The illustration shows a 35-ton ladle being poured with an extra high riser. This is a special feature with these products and makes castings under great liquid-metal head pressure as well as furnishing



MACHINING VACUUM DRUM

large risers in which most of the entrapped sand, gas, etc., is segregated to be removed later. The iron flask rings are lugged together. The small flame shooting from the joints is the gas distilling from the loam, which has been heated to above its kindling point.

The excess metal in the riser is readily removed in a lathe, the operation of which is shown on a drum in an accompanying illustration. In the case of drums, an excess of surfacing material is cast also which is removed at the same mounting on the lathe. In a similar manner, all parts which require perfect lines and surfaces are machined in either a planer or lathe.

The grain of the metal will depend largely on the time of cooling, which will be controlled by the heat of the pour and the time allowed before the casting is stripped. Where a hard and fine grain is desired, the mold is stripped while still at a high heat and the casting air cooled. The core is pulled apart and not taken out whole.

Silicon irons are used where resistance to acids is desired, though time does not permit details to be described here regarding the compositions of each special type of chemical resistant metal. However, special alloys are always prepared under the direct guidance of the metallurgical laboratory to meet the requirements to which the apparatus is to be put in use.

Sizes of Apparatus

As far as the foundry is concerned, there is practically no limit in the size to which castings can be made. Transportation facilities alone govern weights and sizes. For instance, the two dissolving tanks shown on the car weigh but 21 tons each, nevertheless there was only one route out of the several available which had bridge clearance sufficient for them to pass in order that they could reach their destination at Perryville, Md. So 14-ft. clearance can be seen to be the exception rather than the rule. As for weight limits, special six-truck cars are available with well over 100-ton capacity. No single piece of apparatus is likely to stay within the limits set by the car clearances and even approach this weight.

However, industrial chemistry is always demanding larger and larger equipment, and a new method of transportation that is capable of accommodating even the large 400-ton cranes of the foundry has come into vogue. This is by water, through the canal, lake and river route. If the huge ocean liner, the stern half of which is shown on its way to the ocean, only has to be cut in two to meet the water route clearance limit, what chance will the railroads have when really large apparatus is demanded?

Research Laboratories

The research laboratories are composed of two main sections, analytical and mechanical. The first comprises the various chemical laboratories, which are maintained for conducting the analytical work connected with the research department. The second consists of the mechanical testing laboratories containing working units of various apparatus, where practical tests are made on customer's materials to determine the apparatus best adapted to them.

These laboratories are in charge of chemists, metallurgists and experts who are thoroughly experienced in the chemical processes and mechanical operations involved in the use of apparatus.

Vacuum Laboratory

The various determinations pertaining to experiments in vacuum drying and evaporating are performed in the vacuum laboratory. Here are also kept complete records of all tests, with samples of some of the materials tested in various stages of the evaporating or drying process. Information and data pertaining to tests are treated in strict confidence and never divulged except to those entitled to them.

Physical Testing and Microphotographic Laboratory

This laboratory is an example of the care and thoroughness observed in manufacture of this type of apparatus. Not only are all raw materials analyzed chemically, but in addition a tensile test is made on samples of all finished products, which are also microscopically examined by means of the microphotographic camera.

The proper metal mixtures and other data required in the production of the castings used in this work are determined in the metallurgical laboratory before the work is taken up in the foundry.

LARGEST TANKS EVER SHIPPED BY RAIL

Another example of the completeness of the laboratory equipment is the laboratory cupola, a part of the metallurgical laboratory equipment. By means of this cupola metallurgists are able to make actual samples of various metal mixtures for testing to determine the mixture best suited for the purpose intended.

A small electric furnace is also in this room for laboratory experiments in electrometallurgy. Work of a larger scope in this field is carried on in the electrometallurgical development department, adjoining the main foundry.

Testing Laboratory

The testing laboratory contains working units of various apparatus, including each standard type of vacuum drier and evaporator, thus making it possible to conduct experiments on each type, if necessary, to determine the one best adapted for the material being treated.

The apparatus used is of small commercial size, and any results obtained can be duplicated, except as to quantity, in the larger sizes.

Wet Vacuum Pump. Used for producing ordinary vacuum on evaporators. When a high vacuum is required the evaporators are connected to one of the dry vacuum pumps.

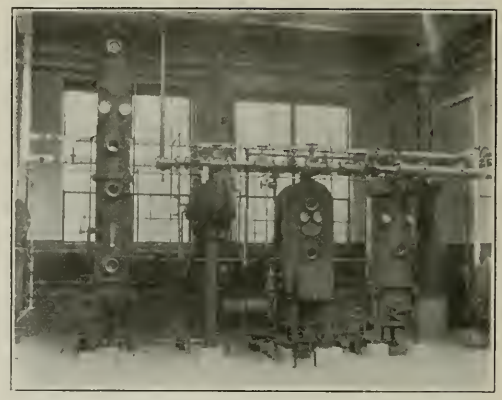
Surface Condenser. Used with evaporators when they are being operated under high vacuum with a dry vacuum pump.

Vertical Tube Evaporator of the Crystallizing Type. Used for evaporating solutions containing salts which become insoluble during the concentration. This small evaporator is equipped with a single filtering device at the bottom, but on larger types two or more salt filters are provided, which can be used alternately without interrupting the operation of the evaporator as each salt filter requires emptying.

Horizontal Tube Evaporator. Used for common solutions which are to be distilled or concentrated to higher densities without the separation of salts, and which have no tendency to foam or produce scale.

In the sizes built for general commercial work the shells are cylindrical. An important advantage of this construction is the possibility of increasing the capacity by simply adding another cylindrical shell and providing longer tubes. This avoids the necessity of installing entirely new equipment when more capacity is required. The shells are made in one piece up to 12 ft. long, thereby reducing to a minimum the number of joints and the chances of leakage.

OCEAN LINER CUT IN TWO BEING CARRIED TO THE SEA



SECTION OF LABORATORY SHOWING HIGH CONCENTRATOR, RAPID CIRCULATION, HORIZONTAL TUBE AND VERTICAL TUBE EVAPORATORS

Rapid Circulation Evaporator. This type is especially adapted for evaporating foamy and delicate liquors. It is economical and capable of high capacities. A special feature of this type is the fact that it can be operated with very small temperature differences, on which account it can be used in multiple effects of many units. This makes for high economy in steam consumption and large capacity of liquor handled.

Other features are as follows: High liquor velocity in the tubes, easy cleaning of tubes from the outside, liquor losses on account of foaming or entrainment reduced to a minimum, large capacity per sq.ft. of heating surface, simple operation. It is also noted for its high efficiency, uniform circulation, substantial construction and moderate cost. The amount of liquor in circulation is very small and the possibility of foaming is reduced to a minimum, as the liquor level is always kept low and the foam is broken up in the upper part of the tube where film evaporation takes place.

High Concentrator. Especially adapted for the high concentration of caustic soda, potash, ammonium nitrate and electrolytic caustic solutions above 36 deg. B. This evaporator produces a very rapid, uniform circulation of the liquor and it is possible to concentrate to high densities that are not possible with evaporators of standard construction.

The high concentrator is also used for liquors separating salts, and especially caustic solutions at high densities, where an all-cast iron construction is absolutely necessary. The tubes are made of alkali- or acid-resisting iron depending on the nature of the liquor to be concentrated. The evaporators can be operated under atmospheric pressure or under a vacuum as may be most suitable for the material being handled.

Special Vacuum Drum Drier. For drying pasty substances. This drier is now in the process of development.

Crystallizer. This apparatus can be operated with or without a vacuum. The jacket is cast integral with the pan, this construction being also followed in the larger sizes. This eliminates all joints as well as the use of bolts, packing, etc. This apparatus can be used for concentrating and crystallizing a great variety of products.

Vacuum Rotary Drier. Used for drying materials that permit mixing or agitation. The interior is equipped with mixing arms and paddles attached to a revolving shaft. In larger sizes this shaft is also a heating tube which assists in the drying.

Vacuum Drum Drier. In operation, converting milk from liquid state to dry form. This drier is also used for drying many other liquid materials. Besides being used on experimental work, this machine is also used commercially for drying smaller quantities of material than can be handled economically in the large apparatus. The results obtained on this machine can all be duplicated, except as to the quantity, on the larger sizes.

Laboratory Shelf Drier, Small Size. This is used very extensively in laboratory and research work. Many concerns use it for conducting tests on their own materials and also for determining in advance how deep to load pans for their larger driers. In this drier the center of the stand forms the condenser, and the base a receiving chamber for condensed vapors.

Circulation Pump for Circulating Hot Water. In making drying experiments it is often necessary to use hot water as a heating medium. This pump is connected to all driers for this purpose.

Dry Vacuum Pump. Two-stage, steam-driven. The arrangement of the piping on this and the single-stage is such that either pump can be connected to any piece of apparatus in the testing room, this permitting the operation of any apparatus with a single- or two-stage pump as desired.

Surface Condenser. The surface condensers are connected to all apparatus. They are so arranged that any valuable solvents from materials being dried may be recovered, and also drained from the condensers without interrupting the drying operation.

Expansion Tank. Used in connection with a dry vacuum pump to collect and reclaim highly volatile vapors which sometimes pass through the cylinder of the vacuum pump with the exhaust air from a vacuum apparatus.

Impregnating Apparatus. Used for impregnating any material with liquid compounds, oils, paraffine, colors, etc. Also impregnating electrical apparatus such as coils, armatures, transformers, etc., with insulating compound.

Industrial Research in England

The British Government has placed a fund of a million sterling at the disposal of the Research Department for the purpose of encouraging industrial research. In order that the assistance rendered may be effective in increasing the initiative and independence of the manufacturers, the Advisory Council for Scientific and Industrial Research has recommended that the new fund should be expended on a co-operative basis, in the form of liberal contributions by the Department toward the income raised by voluntary associations of manufacturers established for the purpose of research. That is, if the firms in an industry which are engaged in the production of similar articles, or alternatively, if the firms in different industries which make use of the same or similar raw or semi-manufactured materials, will combine to improve the processes of manufacturing those materials, the Department will contribute liberally to a joint fund for this purpose.

In this manner, a number of research associations may be formed, some treating the problems of a whole industry, while others may limit their activities to a specific branch of a single industry. The expenditure of the fund for each association will be controlled by a committee or board appointed by the firms contributing to the association and the results obtained will be available for the benefit of these firms only. The Government, however, reserves the right of veto in case any proposal is made by a research association to communicate any results of research to a foreign person or to a foreign corporation, and the right, after consultation with the association concerned, of communicating the results of discoveries to other industries for their use on suitable terms. However, no results will be made available to firms or individuals who are eligible for membership in the association in question but have not joined it.

It is hoped and anticipated that these associations, after having received Government assistance during the period of formation, will eventually prove self-supporting and thus make industrial research an integral part of British industry.

Civil Service Examinations

Associate Chemist.—Applications on Form 2118 will be received until further notice. Requirements; Ph. D. degree or equivalent. Entrance salary, $1800 to $2500 a year.

Junior Chemist.—Application on Form 1312 will be received until further notice. Bachelor's degree required. Entrance salary ranges from $1200 to $1440 a year.

Laboratory Aid.—Examinations will be held May 7, June 4 and July 9 at the places designated on Form 1237. Applications must be sent on Form 304. Entrance salary, $840 to $1240 a year.

All of these examinations are open to women as well as men.

American Welding Society

The first meeting of the American Welding Society was held on March 28, 1919, at the Engineering Societies Building, 33 West 39th Street, New York, and the constitution and by-laws were adopted as recommended by the organization committee.

The following officers were elected: President, C. A. Adams, Cambridge, Mass.; vice-president (for 1 year), J. M. Morehead, New York; vice-president (for 2 years), G. L. Brunner, Utica, N. Y.; directors for 1 year, W M. Beard, New York; M. H. Roberts, New York; M. M. Smith, New York; L. D. Lovekin, Philadelphia; Alexander Churchward, New York; W. H. Patterson, Pittsburgh; Walter J. Jones, Philadelphia; C. A. McCune, New York; directors for 2 years, R. R. Browning, New York; A. S. Kinsey, Jersey City; Victor Mauck, Conshohocken; E. L. Hirt, South Bethlehem; J. F. Lincoln, Cleveland; H. M. Hobart, Schenectady; D. C. Alexander, New York; H. R. Swartley, Jr., Jersey City; directors for 3 years, L. H. Davis, New York; E. L. Mills, New York; D. B. Rushmore, Schenectady; James Burke, Erie; D. H. Wilson, Jr., New York; Hermann Lemp, Erie; C. J. Nyquist, Chicago; Alexander Jenkins, Baltimore.

At a meeting of the directors in the afternoon, W. E. Symons was appointed treasurer and H. C. Forbes secretary.

National Research Fellowships in Physics and Chemistry

The National Research Council has been entrusted by the Rockefeller Foundation with the expenditure of an appropriation of $500,000 within a period of five years for promoting fundamental research in physics and chemistry primarily in educational institutions of the United States. A system of National Research fellowships is to be established, under the administration of the Research Fellowship Board of the National Research Council, the members of which are the following:

HENRY A. BUMSTEAD, professor of physics, Yale University; SIMON FLEXNER, director of laboratories, Rockefeller Institution for Medical Research; GEORGE E. HALE, director of Mount Wilson Observatory; ELMER P. KOHLER, professor of chemistry, Harvard University; ROBERT A. MILLIKAN, professor of physics, University of Chicago; ARTHUR A. NOYES, director of the Research Laboratory of Physical Chemistry, Massachusetts Institute of Technology; WILDER D. BANCROFT, professor of physical chemistry, Cornell University.

Fellowship Appointments.—Candidates for Research fellowships will include those who are brought to the attention of the board by professors in educational institutions and by other investigators throughout the country, as well as those who apply on their own initiative. As a rule, fellowships will be awarded to American citizens who have had training equivalent to that represented by the Doctor's degree, but in exceptional cases this requirement may be modified. The salary for the first year is ordinarily $1500, but this, too, may vary in individual cases. The results of all investigations conducted by Research fellows are to be made available to the public without restriction.

Fellowship Applications.—It is expected that fifteen to twenty Research fellowships will be available during the coming year, and that the number will be increased in subsequent years. Applications for these fellowships should be made on the form provided for the purpose, and should be sent to the secretary of the Research Fellowship Board, National Research Council, 1023 Sixteenth Street, Washington, D. C., to whom all other correspondence should also be addressed. Applications will be received up to Sept. 1, 1919, for fellowships available during the next academic year; but a limited number of appointments will be made on the basis of the applications received on or before April 20, 1919.

Imports and Exports

The Bureau of Foreign and Domestic Commerce of the Department of Commerce reports the following imports and exports for January, 1919:

IMPORTS BY COUNTRIES AND EXPORTS (TOTALS ONLY) OF LEAD AND ZINC

IMPORTS

Articles and Countries	Gross Weight Tons	Contents, Lb.	Value
Lead ore:			
Canada	507	113,618	$5,762
Mexico	4,731	639,817	26,776
	5,038	753,435	$32,538
Lead bullion and base bullion:			
Mexico	9,885,902	9,678,891	$611,716
Zinc ore and calcamine:			
Canada	1,042	894,752	14,969
Mexico	1,298	1,034,319	21,216
	2,340	1,929,071	$36,185

FOREIGN EXPORTS (TOTALS)

Lead pigs and bars		5,666,988	$516,057

DOMESTIC EXPORTS (TOTALS)

Lead pigs—Domestic ore		4,658,421	360,457
Lead pigs—Foreign ore		12,875,887	886,130
Zinc spelter—Domestic ore		10,680,934	1,047,990
Zinc spelter—Foreign ore			
Zinc in sheets		3,408,051	786,798

IMPORTS OF TIN BARS, BLOCKS, PIGS, ETC., BY COUNTRIES AND CUSTOMS DISTRICTS

Countries	Lb.	Value	Districts	Lb.	Value
England	168,108	$137,491	Buffalo	14,552	$5,576
Canada	14,552	5,576	New York	505,336	377,687
Bolivia	125	75	Pittsburgh	560,000	433,949
Chile	970	421	Maryland	112,079	90,651
Straits Settlements	7,341,240	4,853,302	San Francisco	4,096,202	2,602,732
			Washington	2,994,040	1,990,929
Japan	56,033	40,923	Chicago	179,235	129,051
Australia	880,416	592,787			
Totals	8,461,444	$5,630,575	Totals	8,461,444	$5,630,575
				Tons	Value
Total imports of tin ore				2,741	$1,862,148

IMPORTS OF TUNGSTEN-BEARING ORE, AND EXPORTS OF TUNGSTEN AND FERROTUNGSTEN METAL, INTO AND FROM THE U. S. BY COUNTRIES

IMPORTS

Countries	Tons	Value	Countries	Tons	Value
Mexico	58	$63,375	Peru	17	$28,050
Argentina	15	26,907	China	270	293,772
Chile	38	43,511	Hongkong	474	456,219
Colombia	1	1,312			
Total				873	$913,146

EXPORTS

Sweden	12,320	$32,000
Canada	2,000	4,340
Total	14,320	$36,340

U. S. EXPORTS OF TIN PLATE, TERNEPLATE AND TAGGERS TIN BY COUNTRIES

Countries	Lb.	Value	Countries	Lb.	Value
France	143,539	$6,298	Ecuador	12,442	$1,372
Greece	541,000	41,450	British Guiana	43,250	5,012
Italy	287,367	22,984	Dutch Guiana	2,140	260
Portugal	448,850	42,500	Paraguay	608,308	44,427
Sweden	18,588	12,910	Peru	502,099	41,157
Canada	9,892,261	772,236	Uruguay	12,821,033	1,020,312
Mexico	963,643	87,259	Venezuela	2,782	135
Trinidad	133	18	China	2,539,913	221,070
Cuba	924,351	96,393	Dutch East Indies	1,672,553	153,418
French West Indies	45,000	5,225	Hongkong	2,668,115	213,195
			Japan	1,185,637	130,497
Argentina	23,357,488	2,243,685	Australia	1,150	276
Bolivia	153,866	13,454	Philippine Islands	80,000	11,000
Brazil	6,248,288	622,667	Madagascar	2,500	250
Chile	687,605	83,910			
Colombia	564	55	Total	65,854,465	$5,893,425

Effecting and Controlling Crystallization of Ammonium Nitrate

A Description of the Crystallizing Process Employed at the U. S. Ammonium Nitrate Plant—Survey of the Air Conditioning Features Involved and Their Relation to the Entire Process of Refrigeration

By J. ESTEN BOLLING

THE article on the U. S. Ammonium Nitrate Plant which appeared in the last issue of CHEMICAL & METALLURGICAL ENGINEERING discussed in detail the chemistry of the process employed and included a general description of the mechanical operation of the plant.

It is the writer's purpose to describe at greater length the means employed to effect and control crystallization after the liquor leaves the filter presses, passes through the dilution tank and is delivered to the pipe lines.

The entire crystallizing cycle, from the time the liquor leaves the dilution tank until the crystals are removed from the pans, was considered a unit problem and entrusted to the Carrier Engineering Corporation, of New York City.

The liquor, or solution, leaves the filter presses at a temperature of not less than 64 deg. C., being cooled slightly at the dilution tank, and it was decided to pre-cool it to approximately 38 deg. C. before admitting it to the crystallizing pans. To accomplish this the liquor is pumped from the dilution tank to a pre-cooling room where it is passed through a battery of double-pipe pre-coolers.

Cooling the Liquors

These pre-coolers are constructed of 2-in. pipe within 3-in. pipe, the general construction being similar to that of ordinary ammonia condensers, except that a metal spiral was wound around the 2-in. pipe so as to practically fill the annular space between the two pipes. The pitch of the spiral is about 2.5 ft. and it was added to increase circulation, insure uniform cooling throughout the moving column of liquor, and to prevent the inner 2-in. pipe from sagging at the center and thereby causing a variation in the cross-section of the liquor column exposed to the cooling surface. The pipes are 20 ft. long and could be expected to sag considerably, the smaller internal pipe more than the larger external one.

The liquor is circulated through the annular space between the pipes, the cooling water being passed through the inner 2-in. pipe. This was necessary on account of the relative volumes to he handled.

Two batteries of pre-coolers were installed for each unit of four crystallizing rooms, each battery consisting of 5 regular banks and one spare bank. The connections were designed so that any one bank could be cut out of the system for cleaning, without interfering with the operation of the others. When the liquor is drained out the coils can be flushed clean with water, heated by means provided.

A unique feature of the pre-cooling system is, that in order to avoid over-cooling, it is necessary to raise the temperature of the cooling water *above* that at which it is supplied from the mains. The pre-coolers were therefore arranged for recirculation of cooling water, so that a large percentage of the total volume in circulation is recirculated by independent pumps and the required percentage of cooler water admitted by means of an automatically controlled 3-way valve. It should be noted that the cold water supply varies from 0 deg. C. to 29 deg. C. and that the automatic control was designed to constantly maintain the entrance temperature of the cooling water at a degree high enough to prevent "freezing" in case of a complete cessation of liquor flow.

In addition to the automatic regulation of the cooling water temperature, thermostats were placed in the liquor outlets from each bank of coils, so connected that the flow of cooling water is instantly cut off whenever

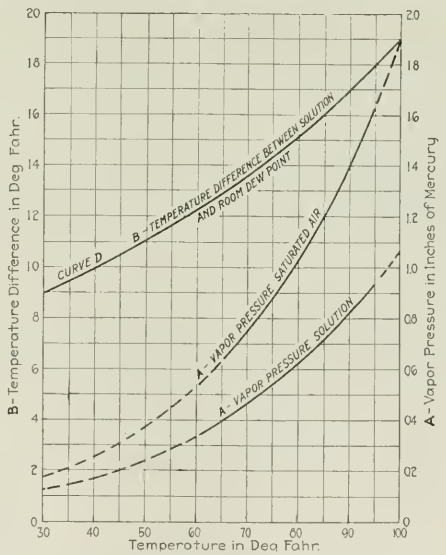


FIG. 1. VAPOR PRESSURE CURVES

the temperature of the liquor drops below the danger point. This was considered necessary because the rate of liquor flow through the coils is determined not by the quantity produced in the digestors, but by the flow into the crystallizing pans, and this flow is variable through rather wide limits, being a hand operation. A condition of complete stoppage was not considered impossible.

The liquor is drawn from the pipe lines into the pans by hand and it is obviously possible for all the pans to be filled at one time so that, for a short period, no liquor would be drawn from the lines. To prevent the freeze which might result under this condition, the liquor feed lines were made in the form of loops which completely encircle the crystallizing rooms. The liquor from the pre-coolers is discharged into an equalizing tank located in the pre-cooler room. From this equalizing tank it is pumped around the loop by independent circulating pumps. These pumps move a volume about twice that which is normally flowing into the pans at any given time, thereby maintaining a constant rapid circulation in the pipe loop. The liquor which has completed the circuit of the loop is returned to the equalizing tank, where it is mixed with pre-cooled liquor from the coils and where an automatically controlled volume of hot liquor, direct from the dilution tank, is admitted to bring the temperature of the entire tank content up to the required degree for safety.

Besides this automatic control of the tank temperature, the liquid level maintained in the tank is governed by a float valve, to prevent overflow. In case the flow into the pans is stopped for a short period the equalizing tank acts as an emergency storage to absorb the fluctuation in flow.

Due to the unusually high temperature of the liquor leaving the filters it is possible to effect nearly two thirds of the total requisite refrigeration in the pre-coolers. The cooling effect of the pre-coolers is equivalent to approximately 1000 tons of refrigeration.

Every precaution was taken to prevent freezing the liquor in the piping system and to this end the design and installation of the entire system was left to the Carrier Engineering Corporation staff of engineers. Dead ends in any part of the piping system were carefully avoided, and means were provided to maintain the liquid temperature in case the flow is stopped, or the system can be immediately drained where necessary, the liquor being stored where crystallization will do no damage.

The saturation temperature of the liquor depends

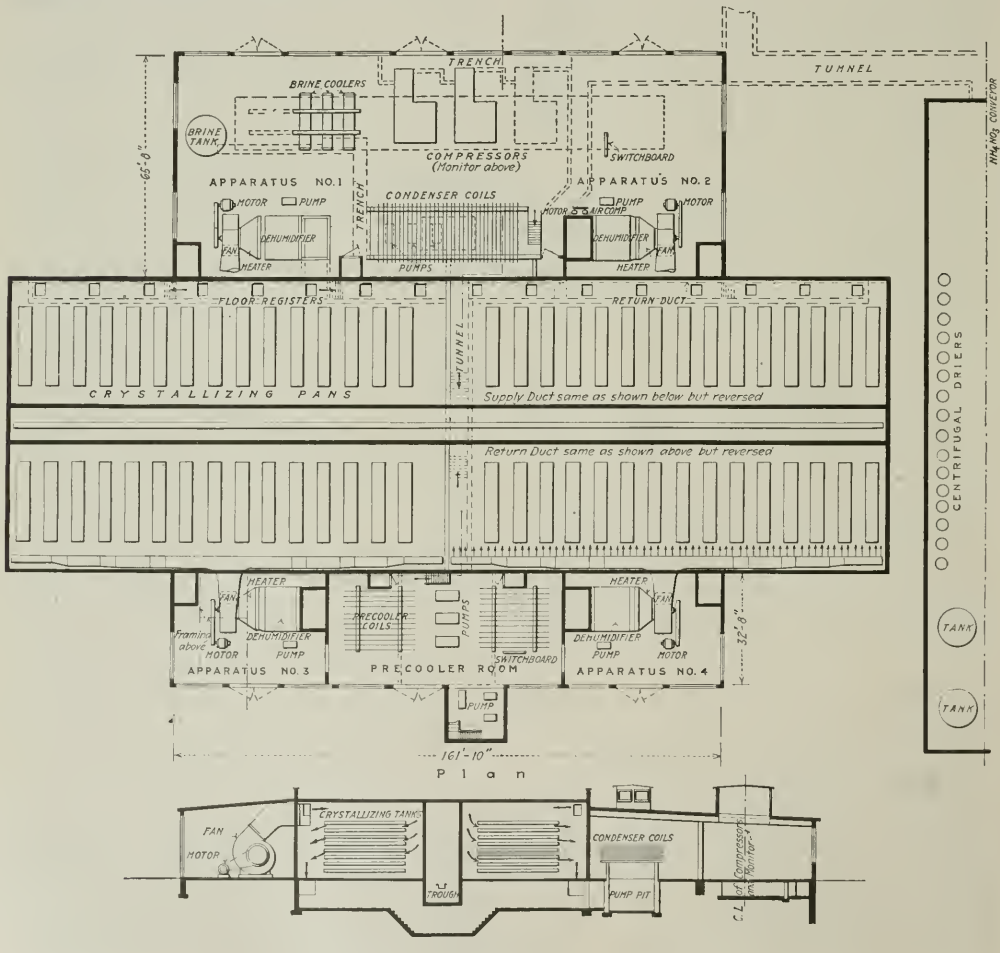


FIG. 2. PLOT PLAN OF APPARATUS

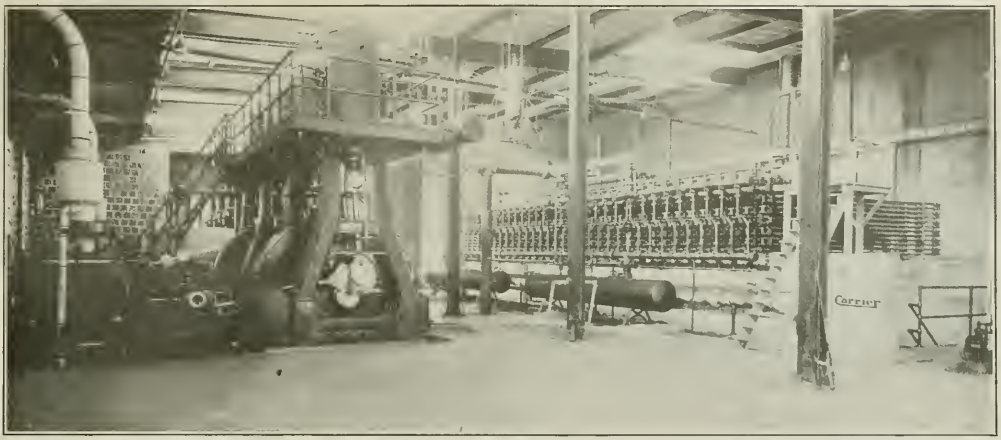


FIG. 3. AMMONIA MACHINES AND BAUDELOT COILS. VERTICAL SINGLE-ACTING COMPRESSORS, STEAM DRIVEN

upon the operation at the dilution tank, and in spite of every precaution it was expected that this would vary considerably. The "safe" temperature was therefore determined for the extreme of this variation and all adjustments made accordingly.

The large pre-cooling coils provide a great excess of hot-liquor radiation in the pre-cooler room and it was therefore necessary to install equipment which would lower the temperature of the room to a permissible degree. Under full operation it is necessary, with the outside temperature at zero F., to introduce cold air in order to keep the room temperature down to 90 deg. F.

For this purpose a small fan was installed and equipped with automatic damper regulation which admits the required volume of cold outside air and recirculates a proportionate volume of air drawn from the room. In summer this fan provides a full volume of outside air, but distributes it uniformly so as to prevent local chilling of the smaller pipe lines or coils, which might be expected if ventilation were obtained through open windows or doors.

Crystallization Department

After pre-cooling the liquor is run into the pans in the crystallizing room.

Due to the very narrow limits between the temperature at which the NH_4NO_3 crystallizes and the temperature at which the other salts begin to crystallize, it is imperative that the cooling be accomplished by the air surrounding the pans, rather than by any form of cooling surface. As pointed out in the previous article, if the filtrate were simply cooled to 20 deg. C. it would be supersaturated with all three salts, NH_4NO_3, $NaNO_3$, and Na_2NO_4, and further fractional crystallization would be necessary in order to separate pure NH_4NO_3. To prevent this sufficient distilled water is added to the filtrate to prevent crystallization of $NaNO_3$ and Na_2SO_4, by lowering their concentration ordinates as is shown in the cycle on page 321.

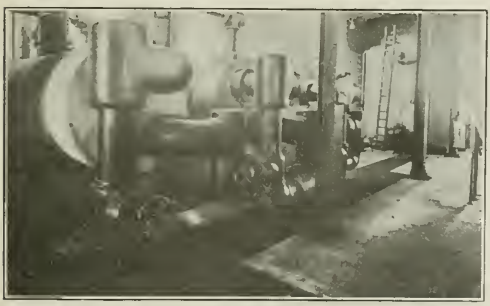


FIG. 4. SHELL AND TUBE BRINE COOLERS

Desirability of Minimizing Evaporation

In order to maintain this balance, which is carefully determined and effected at the dilution tank, and in order to prevent excessive surface cooling, it is desirable to minimize evaporation from the pans, as far as possible. To avoid evaporation it is necessary to maintain a vapor pressure in the air surrounding the pans, equivalent to or greater than the vapor pressure in the liquor at any given temperature while cooling. To maintain this vapor pressure in the air requires a high humidity, since it requires a correspondingly high dew-point. From the vapor pressure curves in Fig. 1 it appears that the highest vapor pressure in the liquor (at 100 deg. F.) is approximately 1.05 in. Hg, while the dew-point necessary to establish a vapor pressure in the air equivalent to 1.05 in. Hg is approximately 81 deg. F., or 19 deg. F. lower. The ideal crystallizing cycle would, then, contemplate an initial dew-point of, say, 82 deg. F. constantly decreasing along the curve "D," so that the vapor pressure in the air would always be maintained at a value slightly higher than the vapor pressure in the liquor. This would prevent all evaporation and still effect rapid and efficient cooling. To accomplish this it would have been necessary to install a Carrier thermotyme regulator and carefully adjust the instrument for the required control. Although the equipment was designed so that a thermotyme regulator could be later installed, it was decided to begin the operation without complicating matters by installing this instrument, production being of far greater importance than efficiency of operation.

A dew-point of 35 deg. F. was therefore fixed, this

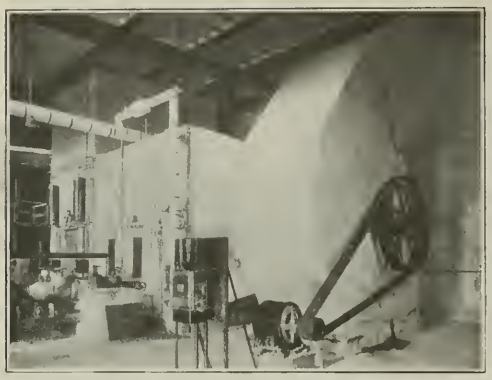


FIG. 5. AIR CONDITIONING UNIT

being low enough to effect rapid cooling and to efficiently utilize salt brine for cooling the air. The dry bulb temperature in the crystallizing rooms was specified at 45 deg. F. (7+ deg. C.) permitting a diffusion of 10 deg. F. This required an air supply of 75,000 cu.ft. per min. to each crystallizing room (or a total of 600,000 cu.ft. per min. for the entire installation), in order to effect the required cooling with the given diffusion (rise in temperature due to heat absorbed from the liquor). To cool the total volume of air to the specified dew-point of 35 deg. F. requires 700 tons of refrigeration.

The crystallizing plant is divided into two main units,

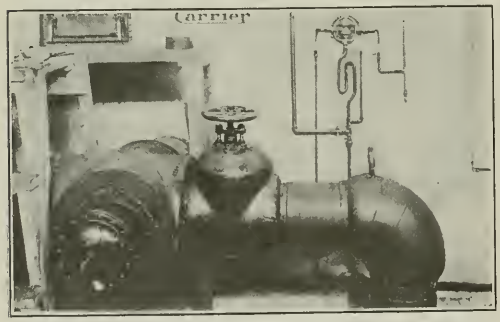


FIG. 6. THREE-WAY VALVE BRINE THERMAL CONTROL

designated as Line A and Line B. Fig. 2 shows a plot plan of one of the crystallizing room units. Since they are exact duplicates this discussion will be confined to a single unit.

Each unit is composed of four separate crystallizing rooms, approximately 36 ft. x 128 ft., each containing 15 tiers of 8 pans each, or a total of 120 pans per room and 480 pans per unit. The volume of each pan is about 40 cu.ft.

The air supply equipment is divided into a separate apparatus for each room, or four complete sets of apparatus per unit.

Refrigeration Equipment

Each unit is supplied with refrigeration from one set of two compressors which supply cold brine to each of the four sets of apparatus. Each compressor set consists of two vertical, single-acting, two-cylinder York ammonia compressors, driven by horizontal Corliss engines (Fig. 3), the machines operating at a suction pressure of about 28 lb. and a head pressure of about 165 lb., and each developing 175 tons of refrigeration, or a total of 350 tons per unit. These machines are cross-connected so that they can be operated as a pair or independently, providing for adjustment of either machine without interfering with the operation of the other.

The compressor sets themselves are also cross-connected with each other so that in event of the complete failure of either set ammonia can be taken from the other unit, as far as available.

Pump-out lines were installed so that any part of the ammonia system can be thoroughly cleansed without affecting the rest of the system.

Three shell-and-tube type coolers, Fig. 4, were installed for cooling the brine. The brine is pumped to each of the four dehumidifiers (Fig. 5), and there

FIG. 7. PHOTOGRAPH OF BUILDINGS SHOWN IN FIG. 2

sprayed into the mist chamber through which the air is drawn in its passage to the fan. The air is thus brought into intimate contact with the finely divided spray of brine and thereby thoroughly cleansed, reduced to the temperature of the brine and completely saturated with water vapor. The temperature of the air leaving the dehumidifier (and hence its humidity, complete saturation being effected) is controlled by means of a thermostat actuated by the air temperature and acting upon a 3-way valve in the brine circulating pump line. This valve (Fig. 6) is so arranged that it governs the relative volume of brine recirculated from the dehumidifier tank (where the spray is collected

FIG. 8. MAIN SUPPLY DUCT, SHOWING EJECTOR NOZZLES

after falling from the nozzles) and the volume of fresh cold brine direct from the coolers. In this manner the temperature of the brine leaving the sprays is accurately controlled.

Since the operation of the control might add sufficient cold brine to the dehumidifier circuit to flood the tank, means were provided whereby a level regulator operates upon the suction of the circulating pump to equalize the volume of brine being removed from the tank and that being added through the automatic 3-way valve. In this manner the liquid levels in the dehumidifier tanks were maintained within a variation of one-quarter inch.

A large brine storage tank was provided wherein the entire volume of brine in the system can be drained while the dehumidifiers and lines are being cleaned. Operation can then be resumed without the delay incident to making up a new charge of brine.

Brine concentration is maintained by the addition of salt and not by evaporation. The concentrator consists of a small tank placed within the large storage tank. This tank is equipped with tangential jets and so valved that part of the recirculated brine can be by-passed into the jets which are arranged to act against a charge of

FIG. 9. INLET END OF DEHUMIDIFIER, SHOWING COMPRESSED-AIR CONTROLS

salt. The smaller tank overflows into the larger storage tank, providing a simple and effective means for maintaining concentration.

Three Brine Circulating Pumps

Three brine circulating pumps were installed as shown in Fig. 2. Two of these are used for regular operation, the third being a spare, so connected that it can be used for operating the concentrator when desirable, providing a quick concentration.

The length of the brine supply lines is so great that the movement of a maximum volume at certain times sets up a high frictional resistance which varies, of course, from a maximum to practically zero in proportion to the volume of brine being moved. Such a variation in pipe friction would cause a corresponding variation in delivery pressure at the 3-way valves and seriously impair the accuracy of the control. To obviate this variation a special pressure regulator, built by the Taylor Instrument Companies, was installed in the lines, and regulates the delivery pressure at the 3-way control valves between 18 in. and 20 in., with great accuracy.

The thermostatic control which actuates the 3-way brine mixing valve is in operation during the summer season only. Whenever the atmospheric temperature is low enough to provide the necessary cooling, the compressors are shut down and this control is adjusted to operate 3-way mixing dampers, recirculating part of the air from the room, adding the requisite volume of cold air from the outside, and affording a relief for an equal volume through a vertical exhaust tower (Fig. 7). In the summer these dampers are disconnected entirely and the openings closed with heavy tight-fitting doors.

The roofs of the crystallizing rooms are surrounded with a water-tight concrete wall about 10 in. above the roof level. The basin thus formed is filled with water to a depth of about 8 in. The evaporation of this water, in the summer season, absorbs the greater part of the direct sun heat and greatly decreases the loss by radiation.

Air Conditioning

After the air has been conditioned in the dehumidifier it is drawn into large Buffalo Conoidal fans and blown into the crystallizing rooms. The accuracy and sensitiveness of the controls is of little value unless the air distribution within the rooms is uniform and positive. Distribution is effected by means of the Carrier Ejector System, shown in Fig. 8. The circulation is indicated by the arrows in the elevation shown in Fig. 2. The fans discharge into the main trunk duct. From this duct, at regular intervals, nozzles project at right angles. These nozzles are so arranged that the kinetic energy of the high-velocity jet of air is utilized to set up a suction or "ejector effect" which causes a large percentage of the room air to be drawn into circulation. Thus the actual movement of air *within the room* is many times the volume handled by the fans. The path of the circulation, as indicated by the arrows, is across the top of the room, back through the pans, and out through the return duct, which is placed beneath the floor directly under the supply duct, as shown.

This system insures absolutely uniform distribution, and effective and positive velocity, minimum consumption of power at the fans, and enables an apparatus of small capacity to perform work usually requiring much larger, and correspondingly more expensive, equipment.

Accurate Control of Temperature and Humidity of Air of Great Importance

It is essential that the temperature and humidity of the air be controlled with the greatest accuracy, as a drop of a few degrees will begin to crystallize the undesirable sodium salts. From the first day of operation the control was so accurate that no difficulty whatsoever was experienced in holding the variation within a negligible range. All of the thermostatic controls employed act by the expanding and contracting effect of temperature on metal, which effect is utilized to operate a small air valve. The movement of this valve admits or releases an air pressure of approximately 15 lb. per sq.in. which acts upon diaphragm valves or diaphragm motors as required. Fig. 9 shows two of the control panels with small belt-driven air-cooled compressors for maintaining the compression.

It should be remarked that this installation is particularly significant because it again demonstrates the practicability of air conditioning apparatus on a large scale, where dehumidification requires mechanical refrigeration, and where immense areas must be controlled with a precision equal to that of the finest laboratory processes.

New York City.

CONTACT SULPHURIC ACID PLANT, AREA B.

Erection of Huge Sulphuric, Nitric, Mixed Acid and Denitrating Plant Under War Pressure

Construction of One of the Largest Acid Plants in the Country, Under Adverse Conditions—A View of the Situation in General With Methods of Construction

By H. E. and C. E. HOLLISTER

THE construction of one of the largest acid plants of its kind in this country and possibly in the world was started on a river bottom farm, still covered with corn stubble, in March, 1918. The weather was bad—cold and extremely rainy. For a month the sunshine was a rare sight. The frost had just left the ground and a wagon buried to its body was a common sight. A bull team, although perhaps considered by many as out of keeping with modern construction, was a valuable asset and the only certain method of transportation. Corduroy roads had to be built for trucking, plank runways for handling material in wheelbarrows and hand carts, but with all handicaps the wheels were started on an arranged schedule, with a fixed goal, and except for modifications made to suit uncontrollable conditions due to other war requirements of the country, they continued to turn as desired throughout the job.

Acid Plant

The acid plant was a portion of an explosives plant being built for the Government. The trouble in one part was common to the others and all work had to be co-ordinated to avoid undue confusion.

The acid plant covered roughly 110 acres and formed rather a triangular shaped plot, as seen on the general outline plan. The east side was bounded by the main line railroad tracks and a portion of the sorting yard, the west side by the river, while the other sides were boundaries of other areas of the explosives plant. (See Fig. 1 showing general layout of plant. Buildings shown in solid were required first. Each unit as numbered was a complete process in itself and put in operation in succession.)

The contact (sulphuric acid) plant consisted of seven units with capacity of 560 tons of oleum per day, with sulphur storage, building and apparatus for preparing platinum mass, acid storage tanks, etc.

The nitric acid and mixed acid plant consisted of four units with an available capacity of 720 tons per day, with a working storage to hold 20,000 tons of nitrate of soda, and an emergency storage for a surplus of 15,000 tons, also bag washing buildings, storage buildings, etc. The acid mixing plant was arranged to take care of the full output of the nitric plant, with a 30 per cent excess for emergencies. There were offices, service buildings, machine shops, compressor houses, fuel storage and other accessories erected for use of both plants.

In addition to the nitric and sulphuric acid plants, there was erected a denitrating and concentrating plant to handle 480 tons of spent acid from a cotton nitration plant, the concentrated sulphuric being returned to the nitric plant for charging retorts, and the nitric remixed at the denitrating plant with oleum to produce mixed acid.

These figures will give some idea of the size of the plant, but as a matter of comparison it is fair to say that before the war a 10-ton oleum unit was an average size. A fair size plant might have four of these units. This oleum plant had twenty-eight 20-ton units. Ten 6000-lb. nitric retorts were considered a fair sized nitric plant at one time, a few explosives plants possibly having as many as twenty. This plant contained ninety-six retorts arranged for a 7500-lb. charge and could, if the emergency had arisen, have handled an 8000-lb. charge.

The whole plant was much more extensive than any previous construction of similar nature. There were those plants which by slow degrees had grown to great proportions, but even in these there was no group of this size more diversified.

There were many handicaps, which were to be expected on a piece of work of this magnitude, also many which were not expected in advance. Large quantities of material were required, which had to be obtained from sources already crowded with orders, and shipped over congested railroads. Special apparatus had to be built and, due to its nature, could only be obtained from a limited number of manufacturers. Although the plant covered a vast area, storage space was limited, and the receiving and handling of materials had to be closely watched to avoid congestion. Labor and specialized mechanics, that should have been plentiful on a Government proposition at that time, were conspicuous by their absence.

The plans were started in New York and outlined enough for preliminary listing of materials, and purchasing was started. Arrangements were made for delivery of materials on certain dates to correspond as nearly as possible with schedules of construction.

Systems of listing on material bills and item lists were adopted and various parts given mark numbers which were used to distinguish them throughout the preliminary work and for use during construction. Considerable work was done to standardize and simplify the apparatus and buildings for the purpose of ease of construction, economy of materials and to expedite erection. It was necessary in many cases to make changes in design to suit the standards of manufacturers or to make it possible for certain shops to utilize materials in stock. This, of course, cheapened the work and greatly assisted in delivery of finished apparatus.

After designing work had reached a proper point and purchasing had progressed to such an extent that the program of delivery was assured, the construction work was started.

Purchasing

A special department, working in conjunction with the agents for the Government and the director's staff, handled the purchasing for these areas. The engineers and technical advisers, with the advice and assistance of the War Department officers, settled questions of quality and type of apparatus or parts.

An attempt was made to have details prepared and orders placed in advance for materials which would require considerable time for completion, so that all parts would come in as required. Orders were placed on basis of price, quality and delivery, and in some cases prices obtained, especially in castings, were on a par with those made to private industries before the war and high prices of pig iron. It was necessary to be reasonably assured before placing an order that the company was in a position to make the deliveries, and had or was in position to obtain the required raw materials without assistance. With few exceptions, the materials and apparatus were delivered as required.

The preliminary work on all the plant was started as soon as conditions due to the severe winter weather permitted, and actual building of the plant began as soon as the needed material arrived. A temporary spur about a hundred yards from the right of way had been laid and a drive was started for one of the permanent tracks

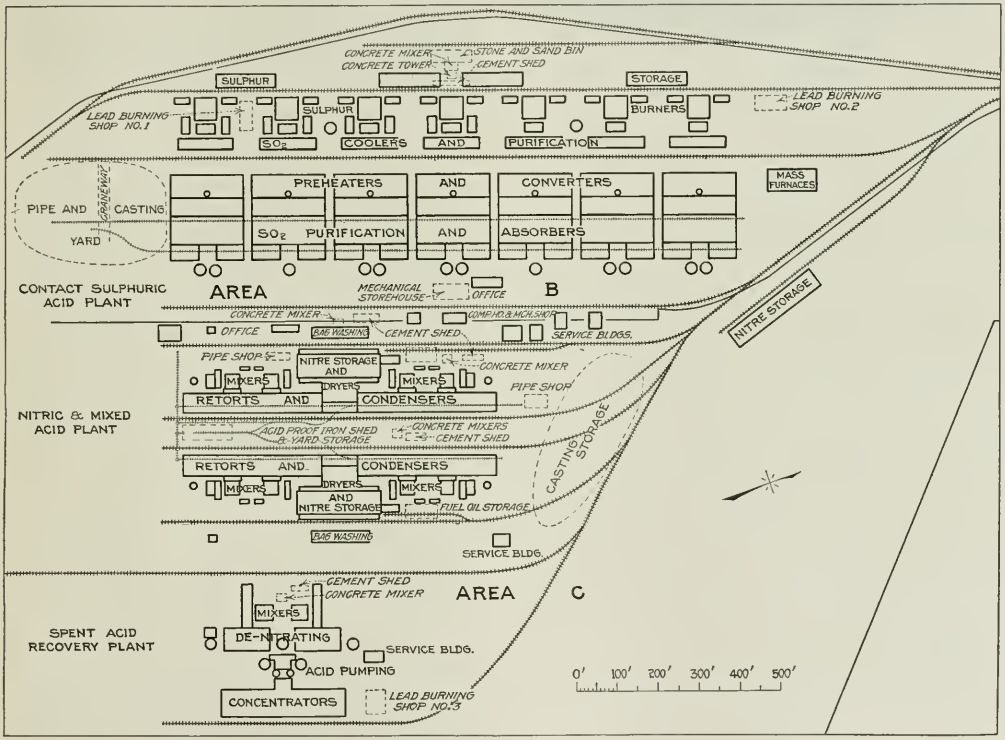


FIG. 1. GENERAL LAYOUT OF THE PLANT

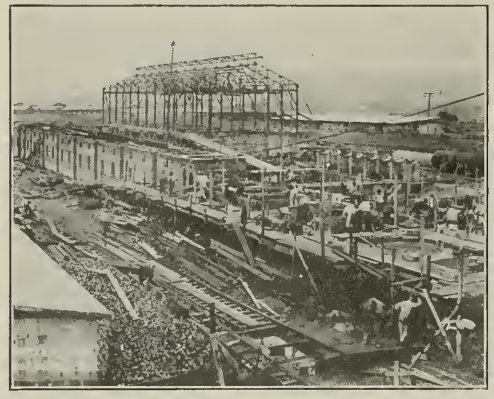


FIG. 2. UNIT 3, AREA C. STEEL WORK OF NITER STOREHOUSE AND RETORT SETTINGS UNDER CONSTRUCTION

through the area. The others were laid as the work progressed.

Lumber and other materials already available were utilized to erect warehouses for construction purposes, offices were erected, which remained as permanent operating offices, but during construction were used for the field office force and draftsmen. Temporary roads, runways, etc., were built and general preparation made for the real construction of the plant. The first excavation was started by hand, and later on steam shovels were utilized where possible. Some forms were also started for the concrete footings.

A large concrete plant with cement storage houses, bins for sand and gravel, and a tower were erected in Area B. This was to supply concrete to Units 2 to 6 by chutes and to the other units by means of concrete buggies. The preliminary starting and early stages of the work were greatly handicapped by the uncertainty of labor, delays in the delivery of some of the construction equipment, and many other annoyances beyond the control of the organization. Housing conditions were at that time insufficient, which caused discontent among the workmen, made worse by the cold weather and rain which fell daily for quite a period. In spite of these conditions a good start was made.

Excavating was done with steam shovels and drag scrapers where possible, and the remainder by hand. Trench diggers were used for pipe line trenches. In most places scrapers were used for back filling in connection with some hand work. In Area B the first unit was excavated mostly by hand, but in other units the greater part was steam shovel work. In this area it was necessary to use dirt excavated from the first four units for building up the grade of the three other units, the ground being highest at the northeast side and sloping toward the southwest.

In Area C footings were excavated through mud in the low ground at Unit 3, and while these were being concreted, scrapers were used to grade land between the two units, the dirt being used as fill west of the unit. After completion of concrete footings, material excavated by steam shovels and scrapers from Unit 1 was used to bring Unit 3 to grade. Excavated material from Unit 2 was also used for back filling in and around Unit 4.

The spent acid plant was on fairly level ground, practically the only excavation being done for the footings. This gave about enough fill for the low spots around the buildings. All the material excavated could be used within a reasonable distance of the point from which it was taken and it was either put in place as excavated, or piled out of the way for distribution later. This was fortunate, as lack of roads made haulage almost impossible. As excavation progressed it was immediately followed by concrete work, which in turn was closely followed by construction of buildings and apparatus.

Concrete Work

Most of the footings were mass concrete. Reinforced concrete was required for some of the walls of buildings and apparatus supports and for storage bins, bag wash houses and trench slabs. Forms were constructed of lumber and made into permanent panels or collapsible forms whenever possible. As many of the footings were duplicates, this saved labor and material and greatly expedited the work.

As many of the walls were high and as it was desirable to fill the whole form at one pouring, the form work had to be well done and carefully tied and braced. No oil or grease was used on forms, but very satisfactory results and a smooth surface were obtained by using finished lumber, and working the concrete well while pouring. Due to the shortage of form lumber, it was sometimes necessary to remove them the morning following the pouring, but care was taken to prevent loading or side pressure from fill to come on the concrete until it was well seasoned, thereby avoiding any injurious results. In most cases after the first units of both Areas B and C were under way, concrete floors were poured at about the same time as footings. By doing this it was not necessary to keep mixers tied up, so preventing interference with other construction. After concrete work in a particular building was completed, the equipment was then available for use elsewhere, and was either used at another point on these areas or turned over to contractors on other areas.

In Area B the first concrete was mixed in small mixers and placed by hand, but later the concrete tower was put into operation and the concrete either shot directly into forms or into hoppers, from which point it was conveyed to the desired locations by buggies. A spur

FIG. 3. COMPLETED STACKS FOR SEVEN H_2SO_4 PLANTS OF WHICH NO. 4 IS UNDER CONSTRUCTION IN THE VIEW

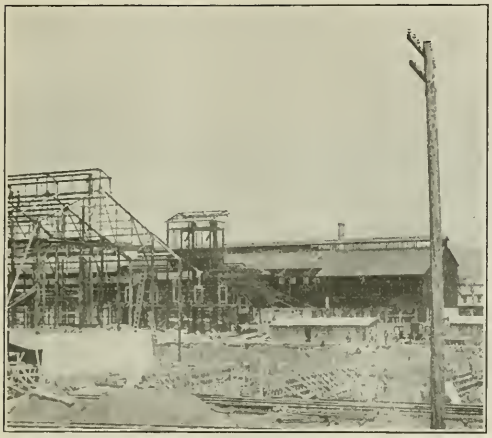


FIG. 4. ELEVATORS, BINS AND DRIERS IN COURSE OF CONSTRUCTION

track was built directly alongside of the material bins as shown in Fig. 2 and material unloaded and delivered to bins by a stiff-leg derrick fitted out with a clamshell bucket. The flow of material from bins to mixer was by gravity. Due to the congestion of buildings and lack of unloading space, the concrete tower was extremely useful and accomplished the desired results. The variation of material and substitution made for sand and stone caused annoyances at the start of the work, but these were overcome as soon as the crew became experienced in handling them. For special mixtures or out of the way places, portable mixers were used.

On Area C the arrangement of buildings made a tower impractical. Austin cube mixers of one-half yard capacity equipped with a self-loading device, filling at ground level, were used. The mixers were cribbed up to such heights that discharge hoppers emptied into a receiving hopper or concrete buggies, and these buggies were pushed along runways above forms. Where possible, mixers were placed alongside of railroad tracks and material used with one handling.

Runways were built up and cleated into sections so that they could be cheaply and quickly changed to any location. These sections were used throughout the job either in elevated positions or on the ground.

Reinforcing rods were cut, bent and otherwise prepared in advance of the concrete work, and were carefully bundled and marked in readiness for use. The steel for the storehouses was prepared in such manner that a section of the building could be assembled in one day. These sections were 50 ft. square and 14 ft. high. Work on the first unit of both Areas B and C was somewhat slow at the start, but rapid progress was made on other units where it was possible to use the forms and standardize the work. The crews were also more familiar with the work than in the beginning.

General Erection

Buildings were constructed with timber, steel and concrete frames, the filling walls being of corrugated asbestos-covered metal, wood covered with roofing paper and battens, tile walls, brick walls and novelty siding. Roofs were of corrugated asbestos-covered metal, wood or cement slabs, with tar and gravel covering. The various illustrations show the types quite plainly. There was considerable delay caused by lack of steel work, its slow delivery being due to manufacturing and transportation conditions throughout the country. Lumber at times ran low, but this construction was most flexible and substitutions could be made which prevented any serious hold-ups of the work. When held up for steel, apparatus was often erected in advance of building. When shortage of any particular materials did occur, the men were immediately shifted to other parts of the job, so that at times work had been started and partly completed at several points. The object was, however, to complete the work in units, as certain buildings were required first to start manufacture. These were indicated and called for in the original schedules and were as shown in Fig. 1. To obtain the greatest efficiency from available workmen, shifting was of course necessary, but they were returned as quickly as possible to the buildings being pushed to completion.

Construction of one unit after another was started in such a manner that the mechanics moved successively from one group to another. This meant that after the first unit was complete and in operation, the successive units were ready at regular periods. Fig. 3 illustrates fairly well units at various stages of completion, each stack being in the center of a unit.

The steel work of the buildings was in many cases also part of the apparatus. It was not always possible or desirable to distinguish between the two for erection purposes. Millwrights, machinists and apparatus erectors were intermingled with other mechanics when and where necessary to properly erect the work, and the work was so laid out and supervised that no confusion resulted. This intermingling of men of various trades required at times considerable tact to keep peace in the family.

Upon completion of the building frame work, and in most cases before the buildings were closed in, erection of apparatus was started. The apparatus in many cases was ready for operation about the same time the buildings were finished. In Fig. 4, center, can be seen elevators, bins and driers in process of erection while building is under way, an example of this type of construction.

The building frame work was simplified as much as possible so as to utilize standard shapes. The steel buildings were fortunately so located that a locomotive crane could be used for placing the steel, in both areas, from railroad tracks. This greatly facilitated erection, especially where it could be unloaded and put directly

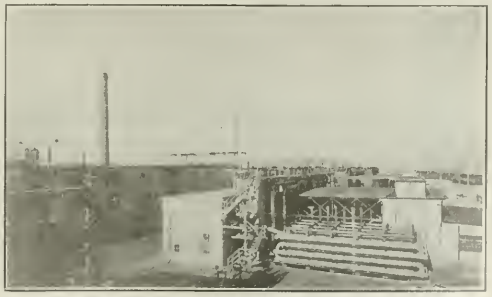


FIG. 5. SULPHUR BURNER BUILDING. SO_2 COOLERS IN FOREGROUND

in place. A narrow-gage track was run from the brick and tile stock piles to buildings under construction and cars either pushed by hand or hauled by an electric storage battery tractor were used to handle the materials. These tracks show in several of the illustrations. Lumber was delivered by cars to the nearest point and distributed by teams.

Apparatus Construction and Erection—Pipe Work

In acid plant work only a small amount of the apparatus can be purchased complete and ready for erection. Most of it consists of material in a partly finished form ready to be built in with other parts to form a certain piece of completed apparatus. Considerable of the apparatus was constructed of masonry with a large amount of lead work, pipe of various kinds and steel work. Mechanics of all kinds were required, and due to the very large scale on which everything was done, it was necessary to train men for many purposes.

Millwrights and machinists were necessary to assemble and erect machines and apparatus which came completed, as well as the building of special apparatus, either by themselves or with other mechanics. Several hundred pipe fitters were required, some on steel and wrought iron piping, which was both flanged and screwed, for handling steam, air, water, acid, oil and other materials. Others were on cast iron pipes which varied in size from two inches to twenty-four inches. These were both flanged and bell and spigot, used to carry illuminating gases, acid gases, acids and water, etc. There was also considerable special pipe and special acid resisting pipe required to handle nitric acid, also brass, glass and special steel pipe.

A pipe yard was located at the north end of Area B. This was the only available open space. Two narrow-gage tracks ran the full length of the sulphuric acid buildings from this yard, and flat cars hauled by electric tractors delivered the material when required. A small overhead craneway with traveling cranes, part of the permanent equipment borrowed from the acid plant, made it possible to reload heavy pipes on the flat cars with little labor. A locomotive crane unloaded the incoming freight cars and placed material in storage piles, as desired. As the freight cars arrived with mostly fixed loads and sometimes with parts not required for immediate use, this method of handling was found very efficient.

At the nitric and spent acid plants in Area C steel

FIG. 6. CONSTRUCTION BUILDINGS. MASS HOUSE TO THE LEFT

FIG. 7. VIEW OF SULPHURIC ACID UNIT

pipe was unloaded for storage as close to the pipe shops as possible. Heavy pipe was delivered direct by locomotive crane to the trenches or places in which it was to be used. Acid-proof iron was included as apparatus and placed in special warehouses.

Lead Work

Lead piping, of which there was a great amount (a good example of which is shown in Fig. 5), was all handled by a crew of about seventy lead burners. Large lead pipes, ells and other fittings were prepared and made up in the lead shops, with all other work which could be handled at this point, leaving the final assembly only for field work. In this way it was possible to utilize the men regardless of weather. The system of narrow-gage tracks made delivery of heavy and bulky parts to their final location an easy matter. The sheet lead as it arrived in carloads was sorted by a locomotive crane and delivered to the proper lead shops. Hydrogen for the burners was both purchased in cylinders and manufactured from spelter and acid on the job. The cylinders were used mostly for assembling lead work in place, as it was more handy and cleaner. Each lead shop was equipped with a very large capacity generator.

The lead burning shops 1 and 3, each located at the most central points, both as to delivery of finished material and railroad facilities, as the handling of the raw materials, as shown by figures given later, was no small part of the job. Lead shop 2, with its storage, scrap melting shed, etc., is seen in the foreground of Fig. 6.

Castings and Apparatus

The heavy castings and parts of apparatus to be erected also required much attention and forethought in handling. A portion of the pipe yard was used for heavy castings and parts of apparatus. The same cranes and industrial cars handled this material. All materials were reinspected before erection, and by the use of the overhead cranes, parts could be handled, sorted and stacked as desired. In this way there was no confusion and a check of stock on hand could be made very quickly.

Tanks were taken from cars and placed directly on foundations as often as possible, with the exception of those to be erected in place. In this case the sheets were taken from cars by cranes and placed as near the permanent location as conditions would permit. As most of the tanks were behind schedule in delivery, all footings were completed in ample time and this portion of the program worked out very successfully.

At Area C, especially in the nitric acid plant, there were many heavy castings. The retorts weighed about

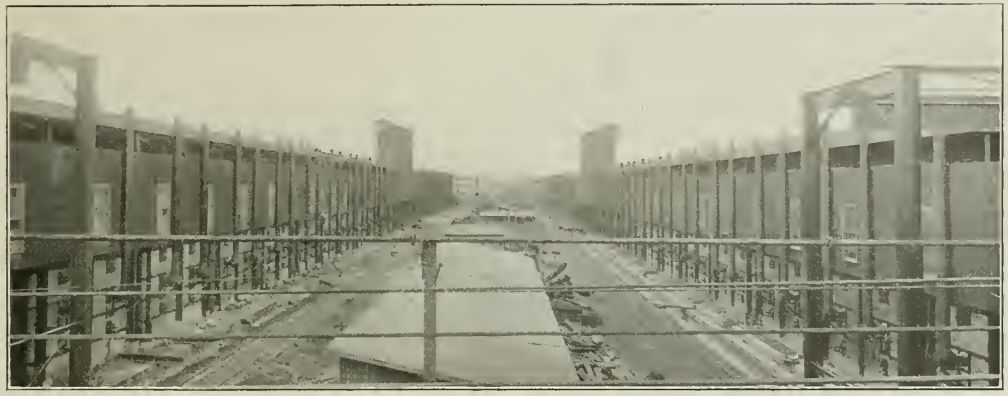


FIG. 8. NITRIC ACID RETORT AND CONDENSER BUILDINGS

eleven tons each. As these came in shipments of two or three, and as it was found more convenient to place them in their settings with a powerful locomotive crane which had to be borrowed, they were accumulated until twenty-four were on hand. The castings as they arrived were unloaded by the regular cranes along the spurs at the south end of the unit and rehandled when enough were on hand. Twenty-four of these retorts as well as their tops could be put in place in six hours. Small castings were sorted, inspected and placed between Units 2 and 4 and taken to location as required by industrial cars.

A warehouse fitted with shelves and bins was erected between Units 1 and 3 at the north end, as shown in the foreground of Fig. 8, where it could be served by two railroad tracks and have wagon delivery. This building was used for the storage of special acid-resisting iron pipe, castings and glass. This material is very brittle and must be handled like glass or porcelain ware. All pieces had to be reinspected upon unloading before being put in stock, as breakage and damage during shipment run high. The warehouse was provided with an industrial track its full length, this track branching out into the four units of the nitric plant. Material was loaded on flat cars as required and distributed. There was practically no breakage of this material after it arrived on the ground, which was considered quite a feat, as in ordinary practice this loss runs very high.

The greater part of the castings for the spent acid plant were unloaded from the cars and delivered by the locomotive crane almost at their destination. Due to the compact formation and nearness of main railroad tracks, an industrial track system was not used. In the other areas they were indispensable and saved much time, labor and trouble.

The apparatus was assembled and erected inside of the buildings by chain blocks and hand derricks. In some parts of the sulphuric and spent acid plants, where continuous replacement of heavy castings is necessary during operation for the purpose of cleaning or replacing apparatus, permanent craneways were erected. These were used for erection purposes during the period of construction.

Mason Work

A great amount of the work, as is usual in acid plants, consisted of masonry. This also varied from common wall and fire-brick settings to acid-tight masonry. Even the acid-proof masonry consisted of various grades of acid-proof brick laid in a number of mixtures of acid-proof cement to suit the various conditions. Fire brick was also of several qualities to meet the heat requirements. Brick work in plants of this nature must be

FIG. 9. TOWER AND PREHEATER BUILDINGS. BRIDGES CARRY LEAD SO_2 LINES

FIG. 10. NITRIC AND SPENT ACID PLANTS

properly and carefully constructed. The life of the plant and economy of operation in many cases depend on the proper carrying out of this end of the work. Many masons are not suited and others without the proper experience must be trained for their particular work. Where possible and practical, mortar was mixed in small concrete mixers, the large number of masons and extent of work making this an economical method. Where parts of the building or other apparatus were built into the masonry, various mechanics worked together or shifted their work to accommodate one another.

Inclines were constructed, operated by gasoline hoists, equipped with narrow gage cars to supply material to towers and other high places. One is shown in center of Fig. 6 at the left of locomotive crane. These were so arranged that a number of towers could be fed from the same incline. Fig 7 is a view of one unit of the sulphuric plant looking west. The nitric and spent acid plant is in the distance. The river is to the foot of the hill in the background, almost half a mile from the camera. Fig. 9 shows a view looking south between the sulphuric buildings. The building to the right, containing furnaces, had to be of steel. The small one at the left is timber, that to the far left is of steel and houses the sulphur burners.

Fig. 10 shows a view of one end of the nitric acid plant with pipe trestle, pump houses, etc., for all acids pumped to the explosive plant. Fig. 11 is the denitrating end of the spent acid. The concentrating plant can just be seen in the distance to the right.

There were used in the construction of these plants roughly speaking 2,000,000 common brick, 110,000 stack brick, 2,000,000 fire brick, 1,500,000 acid brick and 6,000,000 ft. of lumber, 500,000 building tile, 38,000 yd. of concrete, 120 tons of reinforcing rods, 3000 tons of fabricated structural steel, 40,000 ft. of steel and wrought iron pipe, 6000 ft. of cast iron pipe, 8900 tons of special iron castings, 1750 tons of sheet lead, 1314 tons of steel tanks and 715 tons of acid-resisting iron castings.

There was also used 4760 hp. of motors, 158 pumps of cast iron, steel and special acid-resisting iron, 28 low pressure blowers of 2000-ft. capacity each, and considerable quantities of miscellaneous material, among which was 1000 tons of coke, 90 tons of mineral wool, 3700 tons of rock quartz, 128 sets of recording pyrometers, and many miscellaneous articles. There was an average of 20 cars per day to be unloaded and distributed, in addition to which large quantities of all kinds of material were delivered by truck.

The acid plants were built and organization furnished by the Leonard Engineering Co. of New York and Chicago, of which Mr. H. E. Hollister was consulting chemical engineer and technical superintendent. Mr. C. E. Hollister was superintendent in charge of transportation and materials. Mr. W. M. Kallasch was manager.

The Ordnance Department officers in charge of the operation deserve unlimited credit and thanks for their hearty co-operation and assistance. It was through their untiring efforts that many a delay was avoided.

FIG. 11. SPENT ACID PLANT. DENITRATING TOWERS IN THE FOREGROUND

Electrochemistry in Its Human Relations

Electrochemistry Can Contribute to Human Progress and Raise the Standard of Living by Providing Cheap Fertilizer for Increased Crop Yields—It Can Improve Sanitation and Produce New Materials of Construction

By F. J. TONE*

DURING recent years it has been a custom which has now more or less become a dictum that the annual address of the president shall treat of some of the broader aspects of electrochemistry. We have in turn had discourses on the æsthetics of electrochemistry, its external activities, its economic forces, and its public relations. I need offer no apology, therefore, in starting out this morning to make some observations on electrochemistry in its human relations. We are human beings as well as electrochemists, and we may well study the relations of our science to the world problems of today and how we can give most immediate and most effective service for the betterment of human society.

For four years we have been in the thralldom of a great war. We have been passing through a period of violent evolution, the nature and extent of which we have hardly begun to measure or realize. Science and industry, and in fact every human activity, emerges from this world turmoil with new and rapidly shifting viewpoints and new responsibilities, and electrochemistry forms no exception. It is, therefore, profitable at this time to take some survey of our present situation and to forecast our future activities and responsibilities in the new alignment of human relationships. If a new era has begun, what is our part in it?

Big Results of the War

I shall not try to outline any "fourteen points" of future social progress or to say whether some of our values by which we measure such progress are true or false, but one or two things can be stated with a fair degree of assurance. As one of the big results of the war new and better conditions of living are demanded by the masses of the people in all countries. If a higher plane of living in the matter of food, clothing, housing, fuel and sanitation is to be established, and if shorter hours of labor and more opportunity for recreation and self-improvement are to be the order of the new day, this can only be bought about by vastly increasing the production of all the essentials which enter into the needs of modern society. Not forgetting such factors as co-operation, efficiency of organization and distribution and elimination of wastes, production can be increased principally in two ways, first, by using labor more efficiently, and, second, by further supplementing and supplanting labor by the chemical and mechanical instrumentalities of industry. Either we must get more out of labor or we must stimulate the discoveries that will make labor more productive than before. If the world is going to work less, science must work more. The work of the world cannot be done in a six-hour day and a thirty-two-hour week unless applied science gets in a lot of time-and-a-half on week days and double-time on Sundays.

Among the problems of first importance is that of the world's food supply. The crop yields of the world must be vastly increased, and this in the face of a decreasing labor supply. If cereals, cotton and animal fodder must be produced in greater quantity and more cheaply, the answer can only be found in improved transportation and traction for the farmer and in a vastly extended use of fertilizer, and here rests a big problem with the electrochemist.

Judged by European standards, the American farmer is inefficient. He produces fourteen bushels of wheat to the acre, while in Europe the same acre yields thirty. European yields all along the line average from 50 to 100 per cent greater than American yields, and while this increase is in part due to intensive farming, better selection of seed and crop rotation, the big difference is in the enormously greater use of fertilizer. It is of the highest economic importance that the American farmer shall use more fertilizer.

The Electrochemist's Part

The three main elements of plant food are nitrogen, potash and phosphoric acid, and each one of these carries a problem for the electrochemist. The fixation of nitrogen is one of the great triumphs of electrochemistry and the possible exhaustion of the natural nitrate fields is to us no longer a matter of any anxiety. So long as we have energy and air the land need never want for ammonia. Still, the efficiency of the arc process of fixing nitrogen is today less than 5 per cent, and between this figure and the best efficiency attainable, there is certainly breathing space for the most energetic of our research workers. The extension of the cyanamide process has been one of the remarkable chemical events of the war. Its opportunity for peacetime accomplishment is no less, but we still have some distance to go before artificial nitrates can be laid down to the farmer in such quantity and at such price as will mean the doubling of our crop yield.

The Potash Question

The potash problem during the war has been brought into the field of electrochemistry. The Cottrell system of electrostatic precipitation has been successfully applied to blast-furnaces and cement plants, and if all the waste gases from such plants were treated by the Cottrell process, the possible recovery of potash is equal to our pre-war consumption. We can hardly hope that this is commercially possible, but in many localities it will give a permanent source of potash which will maintain its existence under competitive conditions. What the electric furnace can do in phosphoric acid recovery

*Presidential address delivered at the 35th general meeting of the American Electrochemical Society in New York City, April 3, 1919.

is not so well proven. But passing over this, we see that the solution of our national food problem is one in which, despite our past accomplishments, we still have large responsibilities.

In the new order of things we are going to banish the slums and have more healthful living conditions, and the rôle of the electrochemist in sanitation is told in the story of chlorine. We learn that when the armistice was signed we were just ready to deliver each day to our fighting forces on the western front over 200 tons of poison gas. The basis of this great offensive weapon was chlorine, and it was denied its opportunity to demonstrate in a big way what it could do to win the war against the Huns, but I believe it has a far greater opportunity in the germ warfare of peace times.

Chlorine in Sanitation

In starting to investigate the work that chlorine is doing in sanitation, I knew in a general way that it was of growing importance in the purification of drinking water, but upon assembling all the data it was astounding to find that chlorine is today making safe the drinking water of more than 20,000,000 people of this country who dwell in cities. Chlorine is safeguarding one-fifth of our population from typhoid. We learn that a military force or an industrial expedition can go anywhere in the tropics and be at all times assured of potable water if it carries a few pounds of hypochlorite. In the Carrel-Dakin solution for the treatment of wounds, the use of chlorine is defined by a recent authority as the greatest discovery of surgery in the whole war. During the recent epidemic of influenza the number of cases in the cell rooms of two electrolytic chlorine plants located in different States was one-half of that in any other portion of the plants. Starting with a few such facts as these, what more is needed to build up a great structure of organized sanitation with chlorine as its basis? We are looking for an outlet today for a huge producing capacity brought about by the demands of the war. Do not these examples of what chlorine is doing in germ warfare clearly point the way?

Sterilization of Sewage

The sterilization of sewage is as logical a measure of sanitation as the sterilization of drinking water. To be sure, no city drinks its own sewage, but some other city generally does. Why permit Chicago and Milwaukee, Detroit and Cleveland to pollute the waters of Lake Erie, Lake Ontario and the St. Lawrence? Why should Pittsburgh pass its germ-laden water on to Cincinnati and Louisville when an adequate remedy is available at reasonable cost? One hundred and twenty pounds of hypochlorite will sterilize 1,000,000 gal. of screened sewage. A city of 1,000,000 inhabitants can sterilize its sewage at a cost for its chemicals of $360 per day. The cost for a single inhabitant for one year would be about twelve cents.

But the work of chlorine does not stop with water supply and sewage. It should be used to flush and sprinkle our streets, to clean our cars and public buildings and to sterilize our dairies. The organized use of chlorine in sanitary milk production will do more to give our children a pure milk supply than any possible system of inspection.

We are searching for an outlet for our excess chlorine in metallurgy and in organic chemicals. If our electrolytic chlorine friends would begin telling people how they can live in a prophylatic environment, how they can feed their babies pure milk and how they can avoid poisoning their neighbors who live lower down on the same watershed, conditions in the chlorine market would soon be such that they would no longer worry about what the Government is going to do with Edgewood.

Super-Steel

Again, in the metallurgy of steel, if electrochemistry has made great contributions to the art, its responsibilities are no less clearly defined. No one now doubts that we shall soon attain to the super-steel and it is no less clearly indicated that this will be accomplished by the electric steel furnace and electrically produced alloys.

The triplex process using the electric furnace as the third step for the refining operation produces a steel of crucible quality at a cost of a few dollars a ton more than open hearth steel. When it is understood that such steel produces rails which do not break and plates which do not fracture, it will require no advertising campaign in the popular weeklies to bring this product into universal use. Public opinion will demand it.

The alloy steels have made possible the modern automobile, the aëroplane engine and the farm tractor motor. Alloy steels have been a luxury. They have been used only in the vital parts of the mechanism where enormous strains must be met with a minimum weight of material, but their use must be extended. High quality is not incompatible with tonnage. It is the work of the electrochemist to make possible their use as common materials of engineering, thus contributing vastly to improvements in transportation and the mechanical arts. No one needs to have pointed out what this signifies as an economic gain in modern life.

But the field of alloy steels has by no means been fully exploited. The results which the steel maker has achieved with tungsten, molybdenum, chromium and vanadium, marvelous as they are, by no means mark the limit of the art. We now seem to be on the eve of still more important advances based on the use of new alloys including ferro-uranium and ferrozirconium. We hear whispers about a zirconium steel of 300,000 lb. tensile strength and 30 per cent elongation. Not being a steel maker and having no metallurgical reputation to lose, I may venture in my imagination to build an ocean liner or a freight train of this super-steel in which the dead weight is cut in half and the carrying capacity is increased 25 per cent; or, may I visualize the super-steel bridge and finally the super-steel Pullman car, but, in the latter case, we are not so anxious to reduce the weight of the car and save steel. Rather we will make the super-steel Pullman four times as strong with the same weight of steel, and then sleep soundly in the rear section of the rear car while the second section of the train follows one short block behind. Briefly stated, the job of the electrometallurgist is to put super-steel on a big tonnage basis.

Let us now consider energy resources. These are fuel and water power, and their proper utilization not only will reduce the sum total of human toil necessary to run our industrial machine, but is a measure of vital importance to coming generations. Our energy resources are necessary to the functioning of every other resource. They are at the very basis of industrialism, transportation and domestic well-being. Thus they con-

cern society broadly, but they peculiarly concern the electrochemist because cheap electric power is a basic element in electrochemical production. The electrochemist was responsible for the success of the world's first great hydro-electric development at Niagara and became the natural champion of the utilization of our water power resources. But why have we failed to sell this proposition to the man in the street and to those whom in his wisdom he has chosen to legislate for him? There may be many reasons for public indifference to coal economics and the waste of water power, but the fact remains that we have as yet failed to state the simple facts and principles of our energy economics in a way which carries conviction to the people with whom responsibility for action lies. Here are some of them:

1. Coal is our greatest energy resource. It is irreplaceable and notwithstanding an apparent popular belief to the contrary, it is not inexhaustible. The amount available for present and future generations is known to be very definitely limited. The curve of consumption is rising regularly and rapidly and we can compute with a fair degree of accuracy when our magnificent coal reserves will be exhausted.
2. Coal is wastefully mined, wastefully transported and wastefully utilized. If the bituminous coal used for domestic heating alone was first converted into artificial anthracite and the by-products recovered, it would represent a saving of more than twice our entire output of gold for 1917. If our railroads were electrified and fed from central stations recovering the by-products, this saving would be doubled.
3. Fuel and water power are practically interchangeable in industrial economics. The failure to use water power is just as truly a waste as would be the burning of our coal mines and oil wells. If Congress were to enact legislation to set the torch to one-third of all of our coal that was mined in the country last year, it would be no greater an act of folly or a crime than to obstruct water-power development. The utilization of water-power resources will save coal and oil for future generations and release for other useful work in the present generation hundreds of thousands of miners, vast transportation facilities and thousands of railway workers.

Legislation Suggested

Having convinced the people that water power must be developed, perhaps the most difficult part of the problem remains to be solved, which is to arrive at a form of legislation in which the people and the capitalist believe that their respective interests are protected. Passing over the question of Government ownership of water powers, I believe we must all now agree that no legislation for private development stands any chance of enactment which does not carry with it a very much larger measure of public control than would have been acceptable a few years or even a few months ago. Political ideas have changed, and one can plainly observe that public sentiment will not again consent to the development of its water powers as an unrestricted private monopoly. It would not so consent even when awakened to the great economic crime of letting them run to waste. After all, what we want is the power and I believe this Society can not do less than endorse legislation in which public interests are fully protected by control of rates and proper limitation of charter rights. Following this we want Government surveys covering our complete energy resources and their utilization.

My conclusion shall be brief. It is plain that our science faces some of the big human problems of the day. Our opportunity for service was never greater, and I believe it will not be passed by.

Salvaging Industrial Casualties

By Douglas C. McMurtrie

Director Red Cross Institute for Crippled and Disabled Men, Twenty-third Street and Broadway, New York City

In the past, our method of dealing with men permanently disabled in the course of employment has been to pay the worker a pension in the form of compensation, and forget him and his injury. But the cost of disability in the metal trade has not been alone in the premiums paid for casualty insurance. There has been the cost involved in the training, experience and adaptation of a skilled worker who does not return to his job, and the fitting of a newcomer to take his place.

There are three means of reducing and approaching the complete elimination of the cost of disability: first, accident prevention; second, thorough medical attention to minimize the disability resulting from the injury, and third, salvage of the remaining abilities of the worker through rehabilitation for self-support. The first of these has already received wide attention from employers and has wisely been encouraged in a financial way by casualty insurance companies and State funds. The values of the two latter have, however, not as yet been appreciated. Their energetic application would effect a tremendous saving to industry.

Insufficient Medical Treatment

Many injuries from which men would completely recover in a short time under adequate and high-grade medical attention are treated for an insufficient time, or by incompetent physicians, and, instead of a prompt return to work, the case at best drags along over an extended period and at worst becomes chronic or develops into permanent disability. Some States require the insurance carrier to provide but two weeks of compulsory free medical attention to the injured man. For the insurance company to take advantage of this limitation is the most short-sighted policy possible, because for every dollar saved in physicians' or hospital fees, the insurance carrier pays out later ten dollars in compensation. And what the insurance company pays is actually paid by the insuring employers in their regular premiums.

Unlimited medical attention of the highest grade should be an axiom of casualty practice. It should be insisted upon by employer and workman alike. The best outcome of any injury is to have the employee return to his job a well man in the shortest possible time. It is well to develop a science of dealing with cripples, but the ideal is to have fewer and fewer cripples with which to deal.

Rehabilitation for Self-Support

The third method of attack on the cost of disability is rehabilitation for self-support—the re-education of an injured man for an occupation which he can follow, or a process which he can perform, in spite of his handicap. The science of rehabilitation is new, and the experience in it has practically all been gained in the effort to make sound and just provision for the disabled soldier or sailor. Every country among the recent belligerents is to-day operating a comprehensive system of re-education for disabled soldiers, and is placing upon that system more dependence than upon the pension system.

Paying a man a small monthly or weekly stipend on which he is expected to live in idleness is not a very constructive method. With the breakdown of confidence

in the pension system, it was realized that the only real compensation for disablement was restoration of capacity for self-support. It was further realized that very few jobs require all the physical faculties and that in the present-day variety of industrial processes it is possible to find a job in which a man with a given type of disability can function 100 per cent efficient. Some jobs are standing, some seated, others require walking about; some jobs at a bench working on small articles require but little strength, others involve great physical exertion. Still others do not require the sense of hearing; in others the sense of sight is not essential. Finding the future work of the disabled man, therefore, requires expert and painstaking choice, but a successful selection is possible even for the seriously handicapped. The first aim is to place the man back in a different job in his own trade or in a trade closely related. In such a job his past experience will stand him in good stead. Failing this, he can be re-trained for a different line.

Schools for Crippled Men

The process of re-training the disabled is known as re-education, and can best be provided in a special school for crippled men. The first school of this kind in the United States is the Red Cross Institute for Crippled and Disabled Men, established in New York City through the generosity of Jeremiah Milbank. At this school, open to disabled civilians and soldiers alike, six trades are already being taught: artificial limb making, motion picture operating, oxy-acetylene welding, printing, jewelry work, and mechanical drafting. More will be added as the demand develops. Graduates are already giving satisfaction in the jobs to which they have been graduated, so the enterprise has passed the experimental stage. And in the results attained with disabled soldiers abroad there is overwhelming evidence of the logic and practicality of rehabilitation.

The cost of soldier rehabilitation is being met by the United States Government and by the Governments of some of our allies. It will be admitted without argument as desirable that the advantages of re-education be made available to disabled civilians as well, but will not the cost be prohibitive? The fact is that rehabilitation effects a reduction rather than an increase in the cost of disability to industry or to the community as a whole.

A Typical Case

A typical case will illustrate how the saving is effected. A worker in Massachusetts was injured by a fall while working inside a submarine and his hand became permanently crippled. In due course his compensation rate was determined and he was referred to the insurance carrier to be paid $10 a week for a long period, with a maximum total payment of $4000. Since the disability was manifestly permanent, the insurance company wrote the case off its books as a $4000 loss and transferred that amount to reserve to cover the weekly payments. After the compensation had been paid for nearly a year, a new official of the insurance company began looking over the list of men to whom the company was paying compensation. His attention was directed to the man in question and the latter was requested to call at the office of the company. The case was, like many thousands of others, susceptible of rehabilitation for self-support, so the insurance company official put a proposition to the man in very frank terms. "I believe that you can be trained to earn a good living. I want you to understand very clearly, however, that this proposal is to the financial advantage of the company, but I also believe it is to your advantage as well. A total income of $10 a week is not very attractive to you and you would probably rather return to work at a good wage than remain idle. If you will consent, the company will send you to a school of re-education and see if we cannot get you back on your feet in good shape."

The injured man consented to the proposal and the company sent him to the Red Cross Institute in New York. They began to pay him not $10 a week, as required by law, but $40 a week, $20 to him in New York and $20 to his wife at home. The company also paid his traveling expenses in both directions. In eight weeks he was re-educated in oxy-acetylene cutting and welding and returned home. He is now making not only a satisfactory wage but twice as much as he had ever earned before the accident took place.

Every Party in Interest Benefited

In the whole transaction every party in interest was benefited. The man was advantaged in that his general living standard was distinctly raised, and the necessity of working for his living could not be considered as a hardship. The company paid less than $500 for his rehabilitation, and this expense, in conjunction with the $500 already paid in weekly compensation during the first year of idleness, made a total for the case of $1000. It was thus enabled to credit $3000 profit to the account of profit and loss. The community was infinitely the gainer in that the man, formerly an unproductive consumer, became a useful producer instead. The community further gained in the elimination of the disabled man from the category of a prospective dependent, because while compensation might have taken care of him in a very insufficient way during the period of idleness, there would have come a time when compensation ceased and then he would have been in a desperate economic status indeed—confirmed in habits of idleness, untrained for skilled work, and without any source of support.

Revision of Compensation Laws Needed

A more intelligent handling of disability by insurance carriers will, therefore, reduce their expense, and will thus cut the cost of casualty protection to the employer. There is needed also, however, some revision of compensation laws so that there may be definite encouragement to insurance carriers to offer opportunity of rehabilitation and definite encouragement to the disabled men to take advantage of it. Practically every compensation case that has ever come to the Red Cross Institute has come on the day his compensation expired. For one year, for two years, or for four years the man has existed in idleness, drawing compensation, and cultivating habits of indolence. When his support was cut off, he then became interested in re-habilitation. Present compensation legislation tends to encourage the man to remain idle because his payments are reduced by any improvement in earning capacity. A revision of this practice will make for more constructive provision.

In short, the first effort should be to prevent injury, the second to minimize its permanent effects, the third—when disability has ensued—to offset its economic consequences. The execution of this complete program is not only sound humanitarian practice—it is good business as well.

Effect of Certain Accelerators Upon the Properties of Vulcanized Rubber

Experimental Data on the Activity of Certain Organic and Inorganic Accelerators—Magnesia in Small Amount Is Less Active Than Certain Organic Accelerators, and Does Not Impart to the Mixtures the Physical Improvement Characteristic of the Latter

By G. D. KRATZ and A. H. FLOWER*

THE relative accelerating effect of inorganic and organic accelerators has been subject to a diversity of opinion ever since the latter have been employed in technical practice. Likewise, the effect of each upon the quality and physical properties of the vulcanized rubber has been a matter of discussion.

The results recorded in the experimental part of this paper were obtained in the course of several investigations carried on for the joint purpose of determining the relative activity of certain inorganic and organic accelerators, and the permissibility in the use of the sulphur coefficient in evaluating samples of vulcanized rubber known to contain accelerators. As recorded here, this has consisted primarily in (*a*) a comparison of the relative effects of heavy calcined magnesia and an (unidentified) organic accelerator in a mixture containing only rubber and sulphur, and (*b*) a comparison of the effect of larger amounts of heavy calcined magnesia, light magnesia and lime in a mixture which contained an excess of zinc oxide.

Irrespective of the effect of accelerators upon the physical properties of the vulcanized mixture, possibly the advantage most often claimed for the organic variety in preference to inorganic substances is that, in accelerating vulcanization, the former are much more active than the latter and can be used in small amount to replace much larger quantities of litharge, magnesia or lime. Incidentally, the use of heavily pigmented mixtures is avoided by this substitution. Van Heurn[1] and many others[2] have given figures subject to this interpretation. In a recent communication, however, H. P. Stevens[3] has taken exception to this view, and, further, has obtained results which show that magnesia is more powerful than the inorganic accelerator litharge, or even the organic accelerator isonitroso-dimethyl-aniline. While Van Heurn has also given figures for vulcanization coefficients which show that magnesia is more powerful than litharge, unlike Stevens, he found one-fourth of 1 per cent of p-nitroso-dimethyl-aniline to be more active than even 1 per cent of magnesia.

General Part

Although our investigations have not included a comparison of the relative effects of magnesia and p-nitroso-dimethyl-aniline, the organic accelerator which we employed in place of the latter substance was found to be far more active, when used in small amounts, than were similar quantities of magnesia. Likewise, the physical properties of the mixtures which contained the organic accelerator were shown to be superior to those obtained with similar amounts of magnesia. This, however, did not at first appear to be the case owing to discrepancies found to exist when the load required to effect a given extension is taken as a measure of the physical properties[4]. In this instance then, the sulphur coefficient may be said to afford a fair index of the state of cure, as measured by the physical properties, of mixtures known to contain small amounts of either inorganic or organic accelerators.

This statement, however, was not found to be of general application, and certainly is not true for mixtures which contain larger amounts of inorganic accelerators in the presence of an excess of zinc oxide. We have never regarded zinc oxide itself in the same manner as Van Heurn[5], who found it to act as a retardent of the vulcanization reaction. Nor have we, with King[6], classed it, strictly speaking, as an accelerator. Our experience has been more similar to that of Ditmar and Theiben[7], who found that large amounts of zinc oxide effected a slight, and limited, increase in the rate of vulcanization (sulphur coefficient).

On the other hand, contrary to what might be expected, we have found that mixtures which contained fairly large quantities of both magnesia and zinc oxide, when vulcanized to maximum physical properties, had lower sulphur coefficients than a control mixture which was vulcanized to the same degree without the assistance of an accelerator. The substitution of lime for magnesia in such a mixture, however, was found to produce quite a different effect. With lime, after an initial decrease in the sulphur coefficient, the latter value was found to respond to a further increase in the amount of accelerator. This difference in the action of the two substances would indicate that their function in the mixture is not identical.

Our results with heavy mineralized mixtures have shown that such mixtures are not only subject to misinterpretation, but also that (as has already been stated by Eaton and Grantham[8]) the constituents of the mixtures tend to obscure or mask the individual properties of the rubber used. With this the case any formula, such as proposed by Dannerth and Gage[9], is untenable for the valuation of raw rubbers.

Fundamentally, the purpose of any ordinary vulcanization is to obtain the maximum physical properties which the mixture will retain unimpaired over the longest period of time under the conditions to which it will be subjected. Our experience in the past has been that this physical condition may be largely independent of the sulphur coefficient, particularly if the mixture has been vulcanized with the assistance of an accelerator. Generally speaking, we have not found that the sulphur coefficient affords a reliable indication of the physical properties of a vulcanized rubber mix-

*Read before the New Jersey Chemical Society, Jan. 13, 1919.

ture or that it can be taken as a measure of the state of cure except possibly in the case of mixtures which consist of rubber and sulphur only. We agree with Stevens[10], however, that for *hevea* rubber practically all mixtures with a sulphur coefficient in excess of 3.2 will be subject to rapid deterioration.

In a former paper[11] we have given the limits for the vulcanization coefficient of *hevea* rubber at 1.7 to 2.8. Under standardized conditions, the higher figure has been found to be consistently approximated by mixtures vulcanized without the aid of an added accelerator, or with the assistance of one which is only mildly active. The lower figure has been found to apply for mixtures vulcanized with the assistance of even small amounts of powerful organic accelerators or larger amounts of magnesia. The anomaly found to exist between the action of magnesia and lime, however, indicates that a certain amount of reservation should be made in interpreting the coefficients of mixtures which contain either of these substances.

In view of our results as a whole, while we agree with Stevens[12] that the sulphur coefficient is most important as an indication of the ultimate stability of the product, in general practice it should be considered as an indication only. Even in the case of mixtures composed solely of rubber and sulphur we have found it dangerous to evaluate between them on the strength of their sulphur coefficients alone, unless the past histories of the samples in question are definitely known. As Stevens[13] has stated in a subsequent communication, the true value of a product, as expressed by its state of cure, is obtained from physical and chemical tests only when they have been made after a definite period of aging conducted under carefully standardized conditions. Our results along these lines will be reported upon in the near future.

Experimental Part

As a considerable portion of the work described in this part was carried on prior to our repetition of Stevens' experiments, the same sample of rubber could not be used throughout. However, the same sample of rubber was employed for all of the mixtures in each of our experiments.

The rubber used was good quality, thin pale first latex (*hevea*) crêpe. In each instance the sample was subjected to the minimum amount of milling necessary to work in all of the ingredients. Where small quantities of accelerators were used the total time of each mixture on the mill was 18 to 20 minutes[14]; with the mixtures which contained larger amounts of accelerators and zinc oxide this time was increased to 22 to 25 minutes. All mineral substances were previously sieved through a 100-mesh screen.

The heavy calcined magnesia was previously ignited and found to contain 92.73 per cent MgO. Specific gravity 3.24.

The extra light magnesia gave a loss of 4.0 per cent on ignition, after which it was found to contain 94.0 per cent MgO. Specific gravity 2.82.

The lime was air slaked, gave a loss on ignition of 13.46 per cent and contained 55.12 per cent $Ca(OH)_2$. Specific gravity 2.19.

The zinc oxide was lead free. Specific gravity 5.64.

Accelerator "A" was prepared by the condensation of an amine with formaldehyde. It was of C. P. quality.

In all instances, after mixing, a rest period of 24 hours was allowed before vulcanization. A recovery period of 7 days was then permitted before physical tests or sulphur estimations were made. The combined sulphur was estimated by the method of Rosenstein-Davies[15]: the samples, having first been subjected to 24 hours continuous extraction with acetone in a Soxhlet apparatus, were dried in air and then in vacuo at 100 deg. C. to constant weight. The sulphur coefficients given represent the combined sulphur of vulcanization expressed as a percentage of the rubber in the mixture.

$$\text{Sulphur coefficient} = \frac{\text{per cent combined sulphur in the mixture}}{\text{per cent rubber in the mixture}}$$

The physical properties of the mixtures which contained small amounts (0.10 to 1.25 per cent) of accelerators were measured by the method employed by Stevens, *i.e.*, measurement of the load required to effect an extension of one to nine, and also at break for tensile strength and percentage elongation. In making this comparison, figures for both methods were obtained on the same sample or test piece by recording the load required to effect the given extension and then increasing the load and continuing the extension to breaking point. Each figure given in the following tables is the average of at least three test pieces.

Irrespective of the adaptability of the two methods as a means of testing samples of different mixtures, both of them are subject to criticism. The measurement of the load required to effect an extension of one to nine was unsatisfactory in that even small amounts of magnesia decreased the percentage elongation to such an extent that this extension was made just short of the point of rupture, or break. The danger of misinterpreting the results obtained by this method, due to this feature, is commented upon elsewhere in this article. This method would be more generally applicable if the load required to effect a lesser extension was recorded. On the other hand, when tested at break, the samples which contained but small amounts of accelerators had a tendency to be cut by the clamp holding the test piece, before the point of rupture was reached.

Note: The mixtures which contained zinc oxide were tested at break only. All results were obtained on a Scott testing machine of the vertical type.

Experiment 1

In this experiment we first followed the plan outlined by Stevens and have compared the accelerating effect of magnesia against an organic accelerator which we have called Accelerator "A." The effect of these accelerators was tested in the same mixture as previously employed by Stevens, namely, 90 parts of rubber and 10 parts of sulphur[16], with added amounts of the accelerators varying from 0.10 to 1.25 per cent on the rubber content. Vulcanization was carried on in a platen press for 60 minutes at 35 lb. steam pressure (281 deg. F.), after which sulphur estimations and measurements of the physical properties were made on the vulcanized products in the manner previously described.

We found the vulcanization coefficients of the series actuated by our "Organic Accelerator A" to be uniformly higher than those obtained with similar amounts of magnesia. (Col. 3, Tab. I, and Fig. 1). This difference between the results obtained by Stevens and us is readily accounted for in the selection of the organic accelerators employed. His accelerator, as well as our own, is unidentified. When the physical properties of

our two series of mixtures were expressed in the manner adopted by Stevens, that is, by the measurement of the load required to effect an extension of 1 to 9, Accelerator "A" was found to have a slight advantage up to about 0.5 per cent, at which point magnesia produced superior results. (Col. 4, Tab. I, and Fig. 1A.) Thus, the physical properties of the series which contained Accelerator "A" are seen to be at variance with what would be expected from their respective sulphur coefficients, provided that the latter figures can be taken as an indication of the state of cure, as measured by the physical properties.

As the series which contained Accelerator "A" appeared to be much superior to the corresponding mixtures containing magnesia, when judged by the "thumb and tooth," it was felt that the physical properties of the two series were not fully expressed by the above method. They were then expressed in terms of the tensile strength and percentage elongation at break.

When interpreted in light of these results (Cols. 5 and 6, Table I, and Fig. 1A), an entirely different relation was seen to exist. Even in this instance, however, it cannot be said that a direct relationship exists between the sulphur coefficients and physical properties of the various mixtures. In the cases of the mixtures vulcanized with the assistance of Accelerator "A," it is evident from the figures obtained for the percentage elongation at break that this property increased coincidentally with an increase in the tensile strength"; with magnesia, on the contrary, the tensile strength was increased at the expense of the elongation.

This difference in the effect produced in the percentage elongation by small amounts of accelerators prohibits the use of the load required to effect a given extension as a measure of the physical properties of the two series of mixtures. As the percentage elongation of a mixture is increased, by the action of an organic accelerator or otherwise, unless this is accompanied by a corresponding and uniform increase in the tensile strength, a given extension will be effected by a lesser load than would normally be required. This was roughly found to be true with Accelerator "A." On the other hand, when the tensile strength is increased at the expense of the elongation, as was found to be the case with magnesia, it will require an excessive load to effect the same extension. This decrease in the percentage elongation of mixtures which contained small amounts of magnesia was so marked that, with 1 per cent of this substance, an extension of one to nine was produced only by a load just short of that required to produce rupture, or break.

TABLE I.

Accelerator Used	Per Cent Accelerator	Sulphur Coefficient	Load in G. per Sq.Mm. Extended 1 to 9	Tensile Strength in G. per Sq.Mm. (at Break)	Per Cent Elongation at Break
Heavy Calcined Magnesia	0.00	0.684	163	181	962
	0.10	1.012		564	937
	0.25	1.287	501	774	950
	0.50	1.500	633	766	912
	0.75	1.873	832	914	900
	1.00	1.724	886	914	912
	1.25	1.821	883	1002	918
Accelerator "A"	0.00	0.684	163	181	962
	0.10	1.202	402	621	925
	0.25	1.609	630	871*	900*
	0.50	2.079	678	1153*	975*
	0.75	2.347	664	1170*	1025*
	1.00	2.518	636	1250*	1037*
	1.25	3.004	642	1223	1087

* These samples were pinched through by the clamps of the testing machine before the point of rupture, or break, was reached. Consequently, the results for tensile strength and elongation at break are low.

TABLE II.

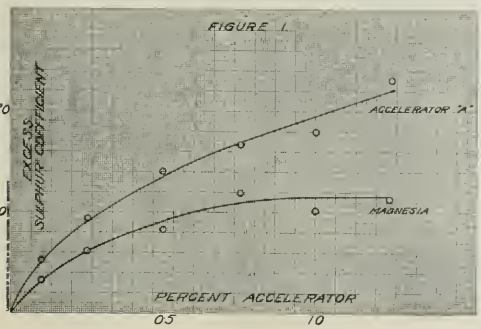
Accelerator Used	Mixture	Per Cent Accelerator on Rubber — 0 Per Cent	5 Per Cent	10 Per Cent	15 Per Cent
Heavy Calcined Magnesia	First Latex	100	100	100	100
	Zinc Oxide	100	92	83	74
	H. C. Magnesia	...	5	10	15
	Sulphur	5	5	5	5
Light Magnesia	First Latex	...	100	100	100
	Zinc Oxide	...	90	80	70
	Light Magnesia	...	5	10	15
	Sulphur	...	5	5	5
Lime	First Latex	...	100	100	100
	Zinc Oxide	...	87	75	62
	Lime	...	5	10	15
	Sulphur	...	5	5	5

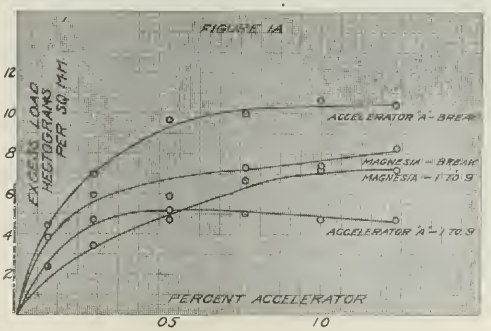
TABLE III.

Accelerator Used	Per Cent Accelerator	Time in Minutes for Technical Cure at 298° F.	Tensile Strength at Break, G. per Sq. Mm.	Elongation at Break, Per Cent	Sulphur Coefficient
Control	0	120	1,331	725	3.075
Heavy Calcined Magnesia	5	90	1,553	700	2.586
	10	75	1,627	725	1.723
	15	45	1,402	675	.....
Light Magnesia	5	90	1,322	700	2.780
	10	45	1,875	750	2.184
	15	40	1,350	775	.....
Lime	5	90	1,294	800	1.990
	10	45	1,565	750	2.926
	15	40	1,512	750	

Experiment 2

In the following work, where much larger amounts of inorganic accelerators were employed, it was desired that the effect of the accelerator as a filler should be minimized to the greatest possible extent. This was accomplished by employing mixtures which contained zinc oxide in such an excess that from 5 to 15 per cent of an inorganic accelerator could be included in the mixture, by replacement of a similar volume of zinc oxide, without decreasing the effect, or function, of the latter





substance (Tab. II). The sulphur content of the various mixtures was also cut down from 11 to 5 per cent, calculated upon the rubber. In this instance, and unlike the preceding experiments, the mixtures were vulcanized to maximum physical properties and their respective sulphur coefficients determined at this point. Portions of each of the mixtures were vulcanized in a platen press at 50 lb. steam pressure (298 deg. F.) over a wide range of times and the correct cure determined as the point of coincident, maximum tensile strength and percentage elongation (technical cure[12]). The sulphur coefficient of each mixture when vulcanized to this degree was then determined (Col. 6, Tab. III).

The results obtained show that, for all three of the accelerators used, the best physical properties were obtained with about 10 per cent of each in the mixture. The effects produced by light magnesia, heavy calcined magnesia and lime ranked in the order named. These differences, however, were small enough to be accounted for in the value of each of these substances as a filling material. However, it is evident that the value of these accelerators as filling materials is of limited extent, because, when present in larger amount (15 per cent), in each case the vulcanized mixtures showed inferior physical properties (Cols. 4 and 5, Tab. III). Moreover, the sulphur coefficients of the various mixtures were not found to reflect, or be a measure of, their physical properties. With both varieties of magnesia, the mixtures which contained 10 per cent of these substances were found to have lower sulphur coefficients than the mixtures which contained but 5 per cent, and the latter had lower coefficients than the control which was vulcanized without the assistance of an accelerator. On the other hand, the results obtained with lime were remarkable in that with 5 per cent of this substance, a much lower sulphur coefficient was obtained than in the case of the control, while with 10 per cent, contrary to the results obtained with magnesia, the sulphur coefficient was increased almost to that of the control.

In explanation of the results obtained with magnesia, we have consistently found that mixtures vulcanized quickly to maximum physical properties with the assistance of accelerators invariably show lower sulphur coefficients than similar mixtures also vulcanized to maximum physical properties but without the assistance of an accelerator. Frequently, much higher physical values are developed by those mixtures which contain accelerators. The same is true in lesser extent when a short period of vulcanization is effected by the use of higher temperatures. It is at least indicated that the time required to effect the cure of a given mixture is reflected both in its sulphur coefficient and physical properties.

Conclusions

In view of the foregoing results we have been led to the following:

1. That the physical properties of vulcanized rubber mixtures are more fully expressed in terms of the tensile strength and elongation at break than by the load required to effect an extension of one to nine.

2. When used in small amount magnesia is less active in accelerating vulcanization than certain organic accelerators, and it does not impart to the mixtures the physical improvement characteristic of the latter substances.

3. With mixtures which contain even small amounts of either inorganic or organic accelerators, no direct relationship exists between the sulphur coefficient and the state of cure as measured by the physical properties of the mixture.

4. When mixtures are vulcanized quickly with the assistance of inorganic accelerators, the correct state of cure, as reflected by their physical properties, is obtained at abnormally low sulphur coefficients.

Chemical Laboratories,
The Falls Rubber Company,
Cuyahoga Falls, Ohio.

References

[1]Intern. Assoc. Rubber Cult. in Netherland Indies. Comm. of Netherland Govt. Inst. for Advising Rubber Ind., Part VI, p. 202.

[2]D. R. P. No. 265,221 (1912). D. R. P. No. 269,512 (1913). Brit. Pat. No. 4263 (1914). *Gummi. Ztg.*, 30, (1916), 303, 326.

[3]*India Rubber J.*, 55, (1918), 25, 5.

[4]This method as employed by H. P. Stevens [*India Rubber J.*, 55, (1918), 25, 5] and others, was found to be subject to correction, as it assumes that, in making comparisons between several samples, similar extensions will be effected by similar loads. Beadle and Stevens [*J. Soc. Chem. Ind.*, 30, (1911), 1421] have previously shown that the addition of as little as one-half of 1 per cent of zinc oxide or talc will produce a marked decrease in the extension of the vulcanized mixture. We have found the same to be true for small amounts of magnesia; certain organic accelerators, however, were found to increase the extension. With such the case, entirely erroneous results were obtained when two series of mixtures, one of which contained small amounts of magnesia and the other similar amounts of a strong organic accelerator, were tested by this method. We have found that comparisons made on the basis of the loads required to effect a given extension are less reliable than those obtained by comparing the tensile strength and percentage elongation at break.

[5]Intern. Assoc. Rubber Cult. in Netherland Indies. Comm. of Netherland Govt. Inst. for Advising Rubber Ind., Part VI., p. 202.

[6]Met. & Chem. Eng., 15, (1916), pp. 231-4.

[7]*Kolloid Z.*, 11, (1912), pp. 77-80. In the course of this work, Ditmar and Theiben also found that lime under vulcanizing conditions showed a greater tendency to form thio-compounds than other substances such as MgO, ZnO, etc. In view of this, and the results obtained in experiment 2, we are led to class the action of lime in accelerating vulcanization as more similar to that of litharge than to that of magnesia.

[8]*J. Soc. Chem. Ind.*, 35, (1916), pp. 1046-50.

[9]*India Rubber World*, 56, (1917), pp. 583.

[10]*India Rubber J.*, 56, (1918), p. 2.

[11]*J. Ind. Eng. Chem.*, 11, (1919) p. 30.

[12]*India Rubber J.*, 53, (1917), p. 220.

[13]*J. Soc. Chem. Ind.*, 37, (1918), p. 280.

[14]Where less than 1 per cent of a mineral accelerator is worked into a rubber, it is extremely doubtful that it becomes uniformly distributed throughout the mass. When used in small amount (up to 3 per cent), and compared on the basis of their respective lead contents, we have found lead oleate to be more active in accelerating vulcanization than litharge. We attribute this largely to the unctuous nature of the lead oleate, which lends itself to a better incorporation with the rubber than litharge.

[15]*Chemist Analyst*, 15, (1916).

[16]The use of such a large quantity of sulphur is deprecated on the ground that it is in excess of the amount required to give a good vulcanization, particularly when employed in a mixture which also contains an accelerator. The excess of sulphur undoubtedly acts as a "filler," the effect of which is commented upon later in this experiment.

[17]Van Rossem (Reference No. 1, p. 214) has already noted that rubbers vulcanized with the assistance of certain organic accelerators show an increase in their percentage elongation at break. In this connection he has also found that, with similar amounts of an accelerator, the vulcanization of a rubber with a low viscosity value will be accelerated more than a rubber with a high viscosity value. This is explainable in light of the results of Spence and Kratz [*Kolloid Z.*, 14, (1914), p. 265], who found that small traces of acid decreased the viscosity of a rubber solution. As Van Heurn (*loc. cit.*) and others have found practically all accelerators of vulcanization to be basic, and retardents to be acidic, the accelerator is doubly effective in the case of rubbers of low viscosity in that it first counteracts the effect of the retarding agent and then accelerates the vulcanization. This will also account for the greater uniformity which is obtained in the rate of vulcanization of rubbers of widely different viscosity values when vulcanized with the assistance of an accelerator.

[18]*J. Ind. Chem. Eng.*, 11, (1919), p. 30.

Australia Prohibits Dye Importations

Australia has, by Government proclamation, prohibited the importation of all dyes (except those of British origin), unless the written consent of the Minister of Commerce and Trade is secured.

Decomposition of Metals—II*

An Application of Theory to the Commercial Problem of Manufacturing Durable Alloys Containing Tin and Aluminium, With an Outline of Recommended Melting, Drawing and Annealing Practice for Certain Munitions

By COL. A. I. KRYNITZKY

THE WRITER studied the question of disease of metals especially in view of its importance in the manufacturing of ammunition. Rifle and gun cartridge cases, bodies, and the time rings of aluminium fuses, tin preserving jackets and tin tubes for some of the types of fuses—all these highly important parts are liable to decomposition under certain conditions of manufacturing and storage.

A noticeable decomposition was observed on the walls of the fuse tin tubes, which were covered with cracks, specks, projections and rough spots. In some cases such decomposition was followed by the partial destruction of metal. As these tubes were drawn cold, the decomposition may be due to the "disease of cold forging." Similar decomposition would be expected from the stamped tin preserving jackets which are used to seal the fuses.

Fig. 12 shows a preserving tin jacket for the 22-second Russian time fuse. This jacket is in the first stage of decomposition. Part of it, as may be seen from the illustration, is already destroyed and the rest is covered with rough spots and projecting grain formations, all of which indicate an imminent decay.

Fig. 13 shows an aluminium body of a Russian 22-second fuse, made in 1904-05 in Keller's factory (Austria), which has decomposed in a typical manner. Here the decomposition affected the body of the piece and was photographed in Fig. 14 at four magnifications without any preliminary preparation. Chemical analysis of this metal showed the following composition: Al, 94.1 per cent; Sn, 3.3 per cent; Cu, 1.8 per cent. Unfortunately the writer was unable to ascertain whether these parts were subjected to cold forging or pressing or to some other process. Fig. 15 shows the same decomposed spot under 80 diameters. It was impossible to polish these places, as the metal was too brittle, and the writer did not wish to impregnate the mass with rosin or similar cement, in order to avoid raising any question as to the meaning of the photographs. It was accordingly very difficult to focus properly the destroyed portion on account of its roughness. The writer succeeded in getting in the picture most of the scattered bright pins and rods among the gray mass.

It is understood that in all cases the diseases and decompositions were observed in very uniform and good castings. No doubt defects in uniformity of the alloys are detrimental to the service rendered by articles, but such defects have nothing to do with the decomposition of the metal as described heretofore.

In discussing the reasons for the "strange and unexplainable" appearance of cracks and other signs of decomposition in cartridge cases, General Matunin (about 1908) advanced the explanation that the cracks are due to the changes in physical condition (temperatures, etc.), chemical factors (moisture and sulphurous gases), but mainly to the inner stresses set up by the cold forging or drawing. This comes very close to Heyn's theory.

Therefore the following factors should be considered as the reasons why decomposition starts and which may take place at any time within the course of years a piece may be in storage:

1. Additional external forces.
2. Stresses, due to the uneven heating and cooling.
3. Surface injuries caused by mechanical action or due to cleaning and washing.

These have already been adequately discussed in the former article, except perhaps the last. Brass pieces under heavy stresses due to cold forging often decompose and are ruined merely by immersing them in mercury or solutions of mercury compounds, or when subjected to the action of ammonia vapors. Sometimes this action is started by merely covering brass with red mercury paint and exposing the piece for a while to the action of moisture, causing HgS to react with the copper in the alloy, decomposing into mercury metal and forming copper sulphide.

According to researches of Henry S. Rawdon[16] on the deterioration of Muntz metal by selective corrosion (dezincification) the results were "strongly suggestive that brass of the α-β type highly stressed is more prone to selective corrosion than when not so, particularly when the stress is highly localized; for example, at the base of a fine haircrack or a narrow groove." Specimens here were immersed for varying periods in 5 per cent sodium chloride solution.

Heyn and Bauer found in their extensive study of the local decomposition of aluminium ware that the metal is affected differently by water and salt solutions, depending upon the condition of the metal and the kind of solution. The decomposition may spread evenly over the whole surface, affecting the underlying metal but little, or it affects the aluminium in spots only, where it becomes covered with white specks, similar to mold. The metal in such spots becomes spongy, peels off and finally is destroyed. The latter effect was observed in heavily forged or drawn samples (for instance in cold drawn sheets). On annealed sheets the water practically had no effect.

Here, of course, the main cause of the disease was cold drawing, and the internal stresses so set up may be

*The first installment of this article was published in CHEMICAL & METALLURGICAL ENGINEERING, Vol. 20, No. 6, March 15, 1919, p. 277.

[16] "Typical Cases of the Deterioration of Muntz Metal (60:40 Brass) by Selective Corrosion," by Henry S. Rawdon. Technologic paper of the Bureau of Standards, No. 103, December 19, 1917.

removed by a proper anneal. Heyn and Bauer mention 500 deg. C. as a proper annealing temperature. The writer also has frequently observed the slight spotty decomposition of aluminium.

It was stated in the *Russian Artillery Journal* in 1912 that in many cases aluminium cables used for telephone, telegraph and trolley wires failed during and after sleet storms without any apparent cause. In such cases the aluminium has shown plainly a crystalline fracture. Aluminium wires suffer particularly near the seashore and in the vicinity of factories emitting vapor and fume of muriatic acid and alkalies. The writer thinks that such cases are evidence of disease in cold-drawn wires, which possibly could have been prevented by previous annealing.

Captain Crard of the French army in his article "Cartridge and Bullet Brass and Electrolytic Copper" (*Rev. de Met.*, 1909) brought forth numerical values for the safe compression of brass without intermediate

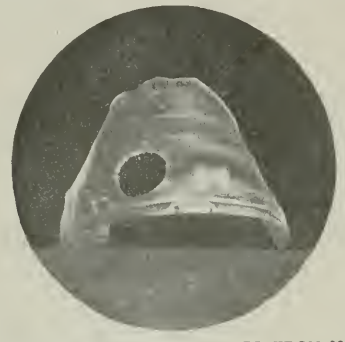


FIG. 12. DECOMPOSED TIN JACKET FROM 22-SEC. TIME FUSE

annealing. He found that the maximum possible deformation for brass should not exceed 200 per cent of the final cross-section, which corresponds to 33 per cent of the original thickness. He stated further that a stable condition follows tempering at from 350 to 450 deg. C. and complete annealing at from 750 to 830 deg. C. After an annealing at temperatures below 350 deg., brass does not remain stable for any length of time, but will develop cracks in the thinner parts. Temperatures above 830 deg. ruin the brass, causing it to lose its strength and durability and to become brittle.

In his treatise[17] Colonel Gronoff discusses the methods for preventing cracks in cartridge cases when stored for a length of time, and states that the cases should be made of metal with a uniform crystalline structure, avoiding excessive deformations in their manufacture, and between passes should be annealed at temperature near 750 deg. C. The mouths of the cases must be submitted besides to a special annealing. As may be concluded from the very extensive researches of Colonel Kourdumoff in Mickall Artillery Academy, Petrograd, Russia (his "Monograph of Copper-Zinc Alloys"), the tempering temperatures for commercial brasses range from about 200 to 400 deg. C.

[17] "Influence of the Methods of Manufacturing on the Mechanical Properties and Crystalline Structure of Worked Brass and Cupronickel and Tendency of These Alloys to Make Cartridge Cases With Ragged Edges," by Gronoff, *Bulletin*, Russian Technical Society, 1911, p. 401.

According to W. B. Price[18], the temperature at which internal strains of brass for cartridge cases are positively reduced if not entirely eliminated is about 500 deg F. (260 deg. C.). The author in his practice in Russia as a rule submitted all rolled and drawn bars and also certain castings of commercial brasses, tin bronze (copper with 8 per cent of tin and about 0.09 per cent of phosphorus), and aluminium bronze (copper with

FIG. 13. BODY OF ALUMINIUM TIME FUSE

9 per cent aluminium) for final heat treatment at 250 to 500 deg. C. (for castings at higher temperatures), according to the mechanical properties desired. Cold rolled rods (also some castings) made of aluminium or its alloys were submitted to a final heat treatment at 450 to 500 deg. C. Thus to prevent deterioration all strained metals must be subjected to a final heat treatment at a certain temperature for each metal. The other methods of removing initial stresses were not mentioned simply because the writer never applied them in his practice and can say nothing positively.

FIG. 14. DECAYED SPOT IN FIG. 13 AT 4 MAGNIFICATIONS

Concerning season cracks in brasses it may be pointed out that according to the researches of Professors Carpenter and Edwards we might expect a transformation

[18] "The Prevention of Season and Corrosion Cracking of Brass Artillery Cases by Special Heat Treatment," by W. B. Price. *Proceedings*, American Society for Testing Materials, 1918, Vol. XVIII, Part II, pp. 179-188.

of β crystals into brittle α crystals[19] to occur in certain brasses under certain conditions.

Proper Manufacturing Procedure for Aluminium Parts and Their Composition

In many countries parts of time fuses are now made from aluminium which contains a little copper and other metals, so that in reality it is a high-aluminium alloy. Possibly, however, copper causes aluminium to be less susceptible to the action of chemical reagents and to decomposition, as defined above. The facts and theories described offer sufficient basis for judging the best manufacturing methods for aluminium parts of time fuses.

Time rings, for instance, which are used in the assembly of the fuses, are flat disks with an open circular powder groove. These rings may be made according to one of the following main methods:

1. Cast and then stamped one way or the other to final dimension.

2. Cast and stamped, leaving in the powder groove sufficient stock for finishing in the milling machine.

3. Cast and compressed without powder groove, which is then milled out.

4. Round rods cast, cold rolled, rings sawed off and finished on machines.

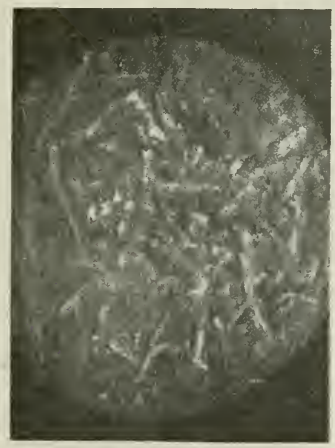


FIG. 15. DECAYED SPOT IN FIG. 13 AT 80 MAGNIFICATIONS

5. Round rods cast, cold rolled, annealed, rings sawed off and finished on machines.

6. Round rods cast, hot rolled, rings sawed off and finished on machines.

Prevention of Decomposition

In regard to prevention of possible decomposition and self-destruction, methods 5 and 6 are, in the writer's opinion, the best. As regards composition it may be pointed out that after many experiments it was found that the best rich aluminium alloy for the time fuses is aluminium with 2.5 per cent to 2.9 per cent of copper.[20] Alloys containing more than 3 per cent of copper are too brittle to be cold forged.

All Russian 22-second aluminium time fuses for the last 11 years in Russia and also in this country were made of this alloy. Although it was very well known that magnesium considerably ameliorates rich aluminium alloys, the writer failed to obtain good results with this element because, first, he couldn't get at that time solid magnesium and was compelled to experiment with magnesium in powder or with small pieces, and,

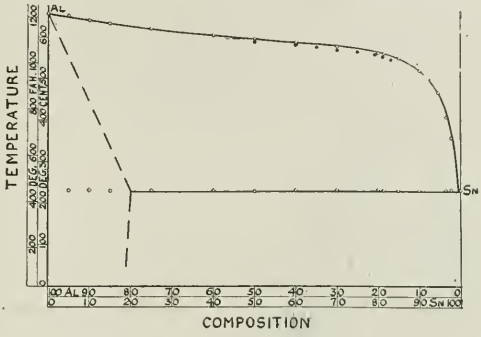


FIG. 16. EQUILIBRIUM DIAGRAM FOR ALUMINIUM-TIN ALLOYS, FROM GULLIVER

second, in rare cases when he succeeded in keeping magnesium within alloy the latter was rather brittle. For the same reason he failed to manufacture duraluminium.

Accelerating Effect of Tin on the Decomposition of Rich Aluminium Alloy

This effect was illustrated in Figs. 13, 14 and 15, showing the decomposition of tin-bearing aluminium alloy. It should appear that such a disintegration occurred not only in such a short time[21] (about eight years) but was to be found only with the above-mentioned time fuses made of an alloy: aluminium with 1.80 per cent of copper and 3.3 per cent of tin.

According to the accompanying equilibrium diagram, Fig. 16, aluminium-tin alloys belong to the class which does not form chemical compounds and when cooled quickly they contain more or less of crystals of nearly pure tin. If there is present free tin in an alloy, we can expect all the phenomena which accompany the decomposition of pure tin. Investigating this question further, we conclude that since pure tin can be found in binary, ternary, or multinary aluminium alloys in its unstable condition, then even a very small addition of tin to the alloy may serve as a source of the "plague." Furthermore, such a small quantity of tin, while decomposing itself, may catalyze decomposition in the other component metals. In this way, tin acts as a poison toward its neighbors.

[19] Although according to O. F. Hudson we have to deal here with a polymorphic change β into β_1. See "The Critical Point at 460 deg. C. in Zinc-Copper Alloys." *Journal*, Institute of Metals, Vol. XII, 1914, pp. 89-99.

[20] It should be noted that this alloy, like other rich aluminium alloys, generally develops some troubles in machining because of the presence of small black particles, which are so hard that the best tools are broken immediately upon touching them. Many experiments were made by the writer with different methods of molding and casting, with the result that this important problem was not solved. Probably these particles are some hard form of carbon, or a chemical compound of carbon with silicon, or of silicon with aluminium. In any case this problem is open to investigation.

[21] It is to be remembered that Russian time fuses are stored in hermetical metal boxes.

The objection may be raised to the application of the aluminium-tin diagram to the ternary alloy aluminium-tin-copper. But in the aluminium-copper equilibrium diagram, Fig. 17, we have a chemical compound or solid solution, so that really there would not be any free copper in the composition used in the fuses which decomposed. Comparing the results of these two diagrams, we may deduce with reasonable certainty that even with the ternary alloy we may expect free tin on quick cooling and without careful annealing.

Therefore, although a small addition of tin to aluminium alloys is very attractive, as it renders the metal very satisfactory for machining, even without a lubricant, and in spite of the fact that small quantities of it may be dissolved by careful annealing this element

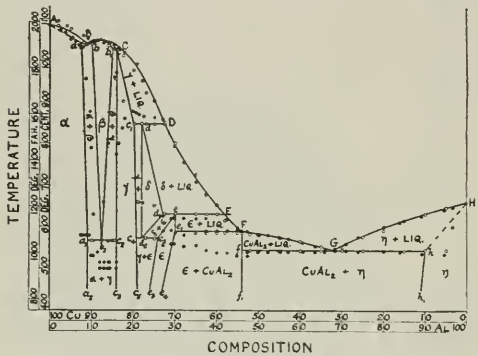


FIG. 17. EQUILIBRIUM DIAGRAM FOR COPPER-ALUMINIUM ALLOYS, FROM GULLIVER

was always avoided and, in the author's opinion, should be avoided when the articles must be kept for a long time, and particularly when cold working is to be used in their fabrication.

As regards a certain contradiction existing between the aluminium-tin alloy solidification diagram which is shown here and the writer's explanation it might be mentioned that at the time when the writer observed disintegration to take place in the aluminium parts of the time fuses considered, he had in mind Portevin's statement[22] in which he wrote in very positive terms that for aluminium-tin alloys there exists neither a chemical compound nor a solid solution.

In the meantime microscopic examination proved, as it was thought, that pure tin occurred in the network and in some spots on the grains and, as is mentioned above, the writer explained the disintegration of this metal as being due to an allotropic modification of the tin in which the tin assumed the brittle form and facilitated disintegration in two ways: (1) Say like bismuth in case of its alloy with copper, where each ductile crystal of copper is surrounded by a weak and brittle envelope of bismuth. (2) As a catalyzer.

Thus the writer explained this phenomenon, but if we have here a solid solution and not pure tin, then his interpretation is incorrect and we must seek some other explanation. Most of these facts and their interpretations are very well known, since they have repeatedly been stated in the literature and if in spite of this the author has ventured to repeat them again it was only in order to bring them together with some of his own observations.

Bureau of Standards,
Washington, D. C.

[22] La présence de l'horizontale eutectique à 229° C. sur toute l'étendue du diagramme montre, qu'il n'existe ni solution solide ni composé défini, à moins cependant que ce dernier ne se forme très lentement. La constation qu'un aliage à 50% Sn maintenu cinq heures constamment agité à 710°–720° sans que cela modifie la courbe de refroidissement rend cette dernière hypothèse improbable." "Aluminum étain," M. A. Portevin, *Revue de Metallurgie*, 1908, 5, pp. 292-293.

A Correction

In the first installment of this article, published in this journal on March 15, a typographical error confused the sense. On page 281, first column, seven lines from the bottom, the sentences should read: According to W. H. Bassett, with wrought brasses in the α phase, the cracks always pass between the crystals. When both the α and β phases are present, the cracks pass through the beta.

War Trade Board Rulings

Importation of Dyestuffs.—The War Trade Board announces that hereafter all applications for licenses to import dyes or dyestuffs must be accompanied by a statement giving complete specifications of the character of the dyes or dyestuffs proposed to be imported. A supplemental information sheet, procurable from the Bureau of Imports, Washington, or from any branch office of the board, should be used for this purpose.

Importation of Ferromanganese and Spiegeleisen.—The restrictions heretofore existing upon the importation of ferromanganese and spiegeleisen have been removed and licenses to import these commodities will now be issued freely when the applications are otherwise in order. Importation of these commodities from the United Kingdom, France, Italy, Belgium or Japan, or from their possessions, protectorates, colonies or dominions, may now be made under General Import License PBF No. 34.—W. T. B. R. 674.

Disposal of Government Spelter

Tentative arrangements for the disposition of the War Department's surplus stock of spelter were made at a conference held in the office of the Director of Sales, which was attended by War Department officials and a committee representing the American Zinc Institute. A complete report was presented by the Government, the figures of surplus shown being considerably less than anticipated by the members of the committee, and it was arranged that the War Department would dispose of its surplus spelter through the zinc committee as representing the producers of zinc. This arrangement will tend to relieve any situation which might arise in the industry from the sale of this property by the War Department itself.

New General Import License

A general import license similar to PBF No. 34, but covering imports into the United States from Mexico, Cuba, Haiti, Santo Domingo and all countries of Central and South America, except British and French possessions, has been issued by the War Trade Board. Individual licenses are required for nitrate of potash, rubber and tungsten ore, in addition to the items mentioned under PBF No. 34 (see page 319), with the exception of ferromanganese and spiegeleisen.

Bituminous Roofing Materials and Construction—I

Genesis of the Roof—Importance of Incline, Types of Roofing Adopted: Flat Roof, Built-Up Felt and Pitch—Roofing Pitches, Weathering Properties—Felts, Sources, Processes of Manufacture

By GEORGE LANDIS WILSON

ROOFS, as developed in the progress of civilization, originally were provided with faces which consisted of overlapping units laid together on an incline so as to break joints with the outer and lower edges toward the drainage point, and each unit projecting beyond the contiguous higher units. Grasses and small twigs commonly known as thatch, slates, flagstone and tiles, shingles made of bark, wood and various composite materials are examples of such facings. All of these required decks, or the equivalent, set at an angle from the horizontal sufficient to direct water to a point where it could not flow back or pass down through the several layers of units and permit leakage through the roof.

For this reason roof design became a problem in the intersection of the faces of pyramids, plinths and polyhedral contours in endless variety.

In the course of time sundry materials in the form of impervious continuous membranes were used as substitutes for the various scale-like applications of material. These were metals, made continuous by the use of soldered seams, continuous membranes built up out of layers of fabric or felt, alternating with various pitch or other water-resisting compositions, and prepared roofings, factory made out of felt saturated with waterproofing materials having the seams cemented together with similar substances. As the use of the various membranes progressed the roof decks used with them were given less slope for the reason that much labor and material are saved when the intricate framings and decks are abandoned, until the "flat roof" became the standard and usual type of construction in many places.

Roof Incline Has Important Bearing

It will be seen that the incline of the roof has a most important bearing in selecting the type of roofing best suited for a given structure. Thus, in general, bituminous roof coverings are divided into two classes; first, those employing a continuous layer impervious to water, the same as in the case of membrane waterproofing used to protect against water pressure below the ground level; and second, those employing separate overlapping units which shed water, as do shingles, tile, etc. While there is a considerable overlapping in the practical application of these two general types, the impervious continuous layer being applicable to any incline, there is a minimum incline below which shingle type is not practicable.

Prepared roofings in roll or sheet form should, perhaps, be considered as a third class by reason of their wider adaptability to almost every roofing condition, although it is generally conceded that they are more serviceable when used on inclines exceeding 2 in. to the foot than on anything less, and that 1 in. to the foot is the minimum, except where unusual and impracticable precautions are taken to avoid exposed nailings and protect against leaks under the exposed laps.

A fundamental to be borne in mind is, in proportion as the roof incline is reduced the greater should be the water-resistant power and assured continuity of the roof covering.

As this article treats only of bituminous roof coverings, it will discuss separately, first, the "built-up" type particularly suited for flat roofs; second, prepared roofings, either in roll or shingle form, particularly suited for roofs of steeper incline.

Conclusive Tests Not Available

Wooden shingles, slate, clay or cement tile, galvanized iron and tin are materials regarding which there is an abundance of general as well as technical information in such form as to be readily available for any one interested in specifying or buying roofing; but such is not the case regarding roofings in which bitumen—coal tar or asphalt—is employed, for the reason that bitumen, which is a hydrocarbon, is the most complex substance with which chemists have to deal. There are probably more than forty different natural sources of bitumens used regularly in the manufacture of roofing, each varying to a more or less degree from the other in chemical or physical characteristics, and each capable to a greater or less degree of mixture with some or all of the others, and each supply, or combination, because of some commercial, physical or chemical characteristics, having its own support among the manufacturers of bituminous roof coverings.

Furthermore there has been no series of tests standardized and accepted as proving that a particular piece of roofing made from a certain material and by a certain process is more suitable for a given purpose than another piece of roofing made from a different material or by a different process. Also, most of the tests that have been suggested are workable only when conducted in a well equipped laboratory, and by some one thoroughly familiar with bitumens and also with their practical uses. Therefore such tests are not available for the average buyer of roofings. As a result each manufacturer has been free to make such claims for his own particular product as his judgment or business necessity has suggested, in most cases without danger of positive and conclusive contradiction; hence there have been large amounts of bituminous roofing materials sold on the basis of claims of general or particular merit which had no justification.

In spite of this condition, which is inherent in the

business and exists today to as large an extent as at any time in the history of the art, the industry has grown during the past seventy years from nothing to such importance that its products annually are used to cover a larger roofed area than are all other types of roofing combined, and in the United States alone represents an investment variously estimated at from $40,000,000 to $60,000,000. This of itself is evidence of the inherent merit of bitumen as a roof covering. The following is offered with the hope that it will in some degree assist the buying public to obtain better value than has been generally the case in the past. We would not presume at this stage in the development of the industry, or of the technical knowledge regarding its supplies, processes and products, to provide an infallible guide.

Functions of a Roof

On the part of the buyer mistakes of judgment, aside from those due to lack of technical knowledge of the commodity, can be traced to confused thinking regarding the results really wanted. Hence it is desirable first to set out clearly the functions of a roof in combination with its joinings and flashings, which serve to complete the connection with projections and walls.

At this time it is also well to remember that every building, except it be a monument, is primarily erected to provide shelter from the weather, and the basic element in such shelter is a serviceable roof. Everything else is really collateral to the principal aim.

Couple with this the fact that in any community the cost of the roofing material used averages less than 1 per cent of the total cost of the finished structures, and misguided effort to make petty savings by cutting either quantity, quality or workmanship here look ridiculous. From the standpoint of the owner, whose entire investment is safeguarded in its most important aspect at such a small relative cost by the roof face, and also of his legitimate agents, the architect and constructing engineer, or contractor, employed and held responsible solely because they are presumed to be skillful and discriminating in selecting that which will be most useful to him, the roof is no place to try experiments. The possible money saving is trifling, while the probable expense, in the event of failure, is large.

Table No. 1—Reasons for Applying Roof Faces, Joinings and Flashings.

(Stated in the usual order of consequence.)

1. To waterproof plane surfaces against rain, melted snow and ice.
2. To join plane surfaces to projections and walls so as to exclude driving rain and snow.
3. To care automatically or compensate for movement and cracks in decks and walls.
4. To protect the most exposed part of premises against spread of conflagration.
5. To provide means for blanketing fire in the building where it starts.
6. To prevent air leaks or drafts, caused by wind.
7. To provide a moderate degree of protection against heat and cold.
8. To provide a presentable architectural finish or uniform effect.

Brief Summarization

The means for accomplishing these results by the use of bituminous materials are briefly summarized as follows:

Table No. II.—Functions of the Substances Used in Bituminous Roof Faces.

1. *Bituminous Waterproofing Material:*
   (*a*) Held as a solid mass of saturant, absorbed in a sheet of felt and on its surface; and also used as a cement at the narrow laps of the sheets when laid. Or
   (*b*) Spread in layers between successive sheets of saturated felt widely overlapped, and also spread over the top to form a continuous membrane.
2. *Absorbent Felt or Textile Used:*
   (*a*) To retain in place greater quantities or more layers of bitumen pitch of suitable softness than would stay by itself or if mixed with pigments or fillers. And
   (*b*) To provide a body of material having sufficient tensile strength and extensibility to bridge all normal cracks and similar changes as they occur from time to time, due to settlement or curing of the walls and decks.
3. *Top Finishing Material:*
   (*a*) To retain an abnormal amount of bitumen pitch in the most exposed place.
   (*b*) To withstand the wear and action of the elements and also abuse by men.
   (*c*) To provide a fire-resisting face to meet conflagration hazards.
   (*d*) To make an attractive, uniform appearance.
   (*e*) On prepared roofing, to supply a dry side, to prevent adhesion and insure easy delivery from the roll when used. Materials so used are cement concrete, bitumen, mastic, vitrified brick, flat tile, small slates, gravel, slag, crushed rock, crushed slate, sand, asbestos fiber, mica flakes or powdered soapstone.

Waterproofing Not a Simple Matter

It is not so simple a matter as it appears to provide a roofing material which will remain permanently waterproof. All viscous materials contain a proportion of oils or oil-like matter having a tendency to evaporate slowly when exposed to the air at ordinary temperatures, precisely as water with a boiling point of 212 deg. F. evaporates rapidly at a temperature of 60 deg. Many of these substances become relatively hard, assuming a crystalline form when they become cold.

The strains placed upon roof faces as the result of extremes in temperature between summer heat and winter cold are evident. In those cities of the U. S. north of 40 deg. latitude, roof surface temperatures as high as 150 deg. above and as low as 20 deg. below zero, F., are usual. It is impossible to make the coefficients of expansion and contraction, due to variable temperature, the same for roof surfaces, roof decks and roof enclosures. The roof face is called upon to provide the element of compensation due to the fixity of construction in the building of which it is a part.

Roofing Pitch

For this reason it is desirable that any bitumen used for roofing materials shall be of a nature that will fuse or run together at a temperature of few degrees below the maximum temperature to which it will be subjected during hot weather. At the same time this fusing quality must be obtained through the presence of oils which are not easily evaporated under conditions of use. The natural oils left in coal-tar roofing pitch during the process of distillation with scientific exactness, to insure a melting point of 140 to 150 deg., as desired, attain these results in an ideal manner. It is difficult to secure equal results when foreign oils are added to bitumen bases. They mix so as to reduce general melting points at relatively high temperatures, say 250 to 400 deg. F., but they do not blend so as to insure the restoration of lesions liable to occur during cold weather.

The causes behind these conditions encountered in practice are indicated by a view of the components in pitch.

Table No. III—Elements in Bitumen Pitches.

1. Gums, which in the last analysis are in the nature of fossilized vegetable tars.
2. Oils which serve as solvents for the gums, and are stable at temperatures less than 150 deg. F.
3. Solvents, which evaporate very slowly at various temperatures lower than 150 deg. F.
4. Fixed mineral matter, composed of infinitely small crystalline units, is usually present.
5. Some asphalts carry wax which is different from gums, because of its coarse crystalline formation, trifling tensile strength and marked inflammability. Such elements are eliminated from coal tar in the making.
6. Traces of sundry alkaline bases which, with the addition of small amounts of water and moderate heat, develop into reagents that attack oils and gums are found in some asphalts. Processes of coal-tar distillation divorce these materials from coal-tar pitch.

Destructive Reactions

In this connection it must be remembered that the water deposited upon roofs is soft water ready to take up promptly in solution every impurity it finds. Roofs are most numerous in places where there are industries and population. The fuels most commonly used in such centers are constantly delivering into the air and depositing upon all the roofs a variety of acid bases which are readily soluble in water. The wastes of civilized life and the ordinary processes of nature constantly produce a supply of micro-organisms which multiply rapidly when water or mere moisture is present and become the source of fungi and molds that cause decay. Weather Bureau records show that rainfall on most occasions is very small in amount, often merely a trace. This means that water sufficient to dissolve all the impurities is frequently present but as a rule not in sufficient quantity to provide a real flow or a flooded washing effect. This chain of circumstances, properly considered, enables one to picture the destructive reactions which repeatedly take place if roofing bitumens contain any susceptible impurities or are so deficient in quantity as to permit any part of the felt to absorb water.

Table No. IV—Some of the Sources From Which Roofing Pitches Are Derived.

1. Tar by-product from coal remaining after production of gas.
2. Tar by-product from coal remaining after the production of coke.
3. Tar produced in the manufacture of water-gas and oil-gas.
4. Deposits of native asphalt which are cut in various oils.
5. Heavy residuals from distillation of petroleum crude oil having asphalt base.
6. Heavy residuals from distillation of petroleum crude oil having paraffine or mixed base.
7. Heavy by-products from treatment of oil-bearing shale rock, lignite or peat.
8. Tar by-products from refining of vegetable oils.
9. Tar and resins from tree exudations and wood-distilling processes.

The methods of treatment to which by-products and residuals are subjected produce pitches of various characteristics. For example, some asphalts are made by oxidizing and polymerizing the hydrocarbons from petroleum sources through the process of blowing heated air or air with steam through the mass for a considerable period of time. Similar treatment with sulphur has been used. The same basic residuals are sometimes concentrated by the mere application of steam heat. The results are not identical. When heated to proper temperature they are all readily absorbed by sheets of felt, but they do not present equal weather-resisting qualities.

The foregoing table does not include all of the possible origins of pitch. Those mentioned are important, and the variety serves to suggest the diversity in the nature of the products which spring from them. Couple with this basic natural variations in the materials used as a starting point, the changes in hydrocarbons caused by heat at different temperatures and during different periods of exposure, the varying degree of skill possessed by operators, or the entire lack of it, the degree of capacity and willingness to test raw materials before refinement or distillation, and the suitability or degree of completeness in the equipment at the works where the pitch is prepared for the market, and there is reason enough to recognize the value to the buyer of established brands sponsored by reputable and responsible manufacturers.

Bitumen as used in saturating felts for roofing must be brought to a state of viscosity which permits it to penetrate the felt. The best method of securing this result is the application of heat, provided the melting point of the pitch is low enough so that the degree of heat required does not damage the felt fabric. Attempts are made to accomplish the result by the use of oils or solvents in the nature of thinners, following the general practice of the varnish trade, so as to secure a saturating material which will penetrate and also set up at normal temperature. This process requires the use of some thinners which evaporate rapidly, and others which evaporate slowly, with the result that the substance of the bitumen becomes cellular and finally impaired to such an extent that the sheet becomes hard and brittle. There are a number of foreign solvents which are effective enough when considered merely as thinners or as waterproofing materials in themselves that are unsuitable for roofing, either because of relatively high inflammability, absence of gum characteristics, lack of synthetic quality, disposition to carbonize at low degrees of heat or readiness to evaporate.

When skillfully used, oils and solvents which have such affinity for the bitumen treated as to form a true combination (instead of a mere mixture) solely for the purpose of lowering the melting point of the bitumen and insuring fixation at normal temperature are serviceable, provided they are stable.

Bitumens used as coatings for prepared roofings and for cementing together and surfacing several layers of felt as applied on a roof surface are generally of a higher melting point than bitumens used as a saturant, but they must also be liquid when used and become solid in a relatively short time at atmospheric temperature. The higher melting point required is obtained either by using different bitumens as a base, or by distillation or oxidation, or by the addition of finely ground inert mineral in the form of silica, slate flour, gypsum, powdered lime, etc. The addition of the inert material is generally for the purpose of lessening the cost, and such mixtures are not as serviceable as pure bitumen except for special purposes outside of the scope of this article.

Felt originally was a specific term used to designate a stuff made of matted wool and hair worked into a compact substance by rolling or pressing and held together by a size made from a weak solution of glue, the dregs of wine or any other convenient viscous material.

Later it became a generic term also applied to any relatively thick sheet which is of comparatively open structure when measured by the standards set up by practice in the paper and cardboard trades. Thus carpet felt, building felt and deadening felt came into regular use at a very early date to prevent the wind from blowing through houses. It was supplied in rolls, as distinguished from flat sheets like paper and strawboard, so naturally fell into a class by itself.

In the United States the history of felt base roofing dates from its employment in gravel roofing, which began about 1845. Naturally the roll felts common in the building trade were used when there was need for a medium to hold a saturation of tar, preliminary to its early application with layers of pine pitch to make a roof face. Coal-tar pitch was first used about 1850. The name "saturated roofing felt" has persisted. The common characteristic of all the felts when considered for saturation lies in their open texture, freedom from inert material and the true absorbent qualities of their fibers, which are truly impregnated and not merely coated by the saturating material. For example, water permeates a body of sand or gravel, yet drains out of it freely and completely; while water impregnates or saturates a sponge or mass of fiber and is removable only by evaporation.

Table No. V—Various Materials Used in Roofing Felts.

1. Animal and vegetable fibers, as wool, cotton and linen, obtained from the maceration of rags and rope.
2. Old paper, jute, flax-tow, hemp, etc.
3. Linters and mill fibers of the waste class.
4. Fibrous wood products obtained by the sulphite and soda process.
5. Mineral fibers, usually of the asbestos series, but sometimes blown slag, mostly non-absorbent.
6. Clay, powdered limestone or like earths used as fillers and weight-makers which absorb little saturant and contribute no strength.
7. Sometimes woven textiles are used as reinforcement sheets.
8. Rarely, wire mesh, wire strands and fiber cords or strings are used for reinforcement.

Processes of Manufacture

The processes of manufacture in the production of roofing felts follow closely the processes established in the writing and wrapping paper industries. However, sorting, cutting, dusting, boiling, washing and beating are not carried so far, and bleaching is unnecessary. The machine used for changing the pulp-like mass into sheets is usually of the cylinder type, although the Fourdrinier type is sometimes used. Press rolls are not set tight, drying cylinders are ample in number and smoothing rolls provide all the finish the dry felt requires. The production of felt for saturating purposes requires a fine balancing of absorbent qualities, tensile strength and durability. "Wool felt" is a misnomer. Felt 100 per cent wool would be entirely unsuited for roofing purposes. A high grade roofing felt contains from 50 to 75 per cent of cotton fiber, a negligible percentage of wool, and oftentimes old papers are used to a limited extent.

Felt when saturated and then surfaced with bitumen becomes roofing and is known as prepared roofing or ready roofing, or felt base shingles, depending on whether furnished in rolls or shingle form, and is a finished product ready for use by itself as a roof covering. Felt when saturated with bitumen but not surfaced must have bitumen used with it when it is applied as a roof covering. While saturated felt by itself will shed water, it is not what would be termed waterproof and will disintegrate rapidly when exposed to the weather. The standard weight of saturated felt for roofing purposes is 15 lb. to the 100 sq.ft., with an allowable variation of one pound either way. Approximately 60 per cent of this weight is saturant and 40 per cent felt, but these percentages vary depending on the viscosity of the saturant and the absorbent qualities of the felt. There are several other weights of felt manufactured because of demand to meet competitive conditions, but there is no reason for any other weight than 15-lb. saturated felt for roofing purposes.

Burning Lime in a Gas-Fired Continuous Kiln

By W. D. Mount

THIS paper is presented for the purpose of drawing attention of lime manufacturers to a system by which lime can be burned economically in a kiln 8-foot diameter with a capacity of 25 tons per day. The ratio of coal to lime is 1 to 5 or 6, depending on the quality of the coal. Cost of repairs per ton of lime is lowered.

The conversion of calcium carbonate to lime is a chemical process which may be conducted without any chemical knowledge, and with but a moderate amount of technical skill. As the carbonate is decomposed at a red heat, it is apparently only necessary to apply the heat for a short period, and the result is lime, regardless of considerations of economy.

"Every step and every factor, however, in the operation of lime burning has a definite significance, and the production of high-grade lime with high-grade economy is as truly a technical process demanding skill and knowledge as any other chemical manufacture. There is need of trained chemists and engineers in this industry to put it upon a distinctly scientific plane."[1]

As every step and factor in the process have a definite bearing on the final outcome, they must be under complete and constant chemical control. Therefore, it is not only necessary that such control be provided, but the design of the apparatus must be of a character that the control can be made effective; otherwise, it will be impossible to realize that continuity of operation and co-ordination of the various factors, so essential to uniformity in quality and quantity of output and the attainment of the highest efficiency and economy.

Engineering Design and Chemical Control Essential

It is doubtful if the salary paid a trained chemist could be invested to better advantage, or be more productive of desired results in any industry than in the manufacture of lime and lime products. However, as already indicated, it is not a problem for the chemist alone, but his work must go hand in hand with that of the engineer. Chemical control cannot be effective in the highest degree unless the design is of a character

[1] Geological Survey of Ohio Bulletins 4 and 5, Orton & Peppel.

to permit the regulation of all those factors having a direct bearing on the final result.

The foregoing statements lead naturally to a consideration of problems of design, preliminary to which, however, it is well to call attention to certain specific factors having a direct and important bearing on the operation of the process. It seems to be the accepted opinion, backed by many years of practical experience, that wood, both technically and as regards quality of product, is the most desirable fuel. It is not my intention, however, to consider the merits of a fuel now unattainable, or at least practically so, but to accept without discussion the most generally available fuel approximating the good qualities of wood, namely, producer-gas made from bituminous coal low in sulphur, in a modern producer-gas machine, so located and operated as to deliver to the kilns the maximum number of B.t.u. per cubic foot of gas. Moreover, that coal will be used, regardless of price, which will give the greatest number of pounds of lime for a dollar.

It would seem axiomatic that a kiln of the shaft type, other things being equal, will have the highest fuel economy when operated so as to be cold at the top and cold at the bottom, and that its capacity, under these conditions, will be greatest when discharging continuously.

"Temperature of burning is an important factor, both in the quality of the product and in the economy of production. Economy in manufacture requires that the temperature of burning should not be greatly beyond that needed for the complete removal of carbon dioxide. . . . The time required for slacking limes burned at different temperatures shows clearly that the sensitiveness of quality of the lime is materially affected by any great overheating."[2]

Importance of Temperature Control

In the use of heat it is necessary, not only as effecting the reaction, but on the grounds of economy, that definite control of temperatures be possible, and in many industrial operations control must be effective to within a few degrees in order to insure the greatest success. Therefore, it seems essential in a well designed kiln for producing lime, that suitable provision should be made for determining and maintaining the proper temperature necessary to the production of the best quality of lime possible from the stone to be burned. Overburning from too high temperatures, or the production of core from insufficient heat are alike undesirable qualities. Fortunately the burning of calcium carbonate to lime is not like some other heat operations, in that a fairly wide range of temperatures is permissible without materially endangering the quality of the product; though from motives of economy, as affected by kiln capacity, it is desirable to approach as near as possible the safety limit of the maximum allowable temperature as the quality of the product will admit. Hence the importance of close regulation, regardless of the considerable range of temperature within which the kiln may be safely operated.

The question of draft is important, not only as affecting the capacity of the kiln, but from the standpoint of economy. Induced draft is preferred, as it is independent of height of kiln, and size of material charged, and can be controlled by the operator in charge.

When de-carbonizing has proceeded to the point where all gas has been expelled, the lime should be promptly removed from the zone of intense heat into the cooling zone; first, to prevent "dead burning" and recarbonization, due to exposure to the combustion gases; and second, that the cooling may be progressive following the principle of the counter current, the hot lime giving up its heat to the incoming air for combustion.

The removal of the lime from the reaction zone to the cooling zone, and its final discharge from the kiln should be continuous. This is an important feature of the design, inasmuch as the discharge mechanism will bring about a slight, but perceptible, movement through the entire charge in the kiln, tending to stabilize the draft, prevent clinkering and holding up of the charge, and improving the life of the brick lining.

Time Required for the Reaction

The length of time required for the limestone to pass through the reaction zone will depend on several factors:

First: The size of the limestone blocks fed to the kiln. The smaller the blocks the less will be the time necessary for the heat to reach their center, other things being equal.

Second: The amount of pre-heating the stone has had, prior to reaching the reaction zone, as well as the kiln pressure.

Third: The nature of the fire, its volume and intensity, and its close regulation.

Fourth: Continuous movement of the stone through the reaction zone.

If a continuous stream of stone can be kept passing through the reaction zone at a rate that would insure the complete burning of the stone to lime, and no more. it would be of advantage to the quantity and quality of the product, for the reason that the constant movement would keep turning the stone, giving equal exposure on all surfaces.

Design of Continuous Kiln

The design of the continuous discharge gas-fired kiln is not, as will be noted in the illustration, altogether a radical departure from the standard of the more modern kilns of the shaft type. Neither the use of producer gas, induced draft, nor the idea of cold lime from the bottom of the kiln are essentially new. On the contrary, these ideas have been tried with more or less success in the past. The principal characteristic of the design is a careful balancing of parts for the specific purpose of permitting that close chemical control, without which continuity of operation, uniformity in quality and quantity of product, and the highest efficiency and economy are impossible.

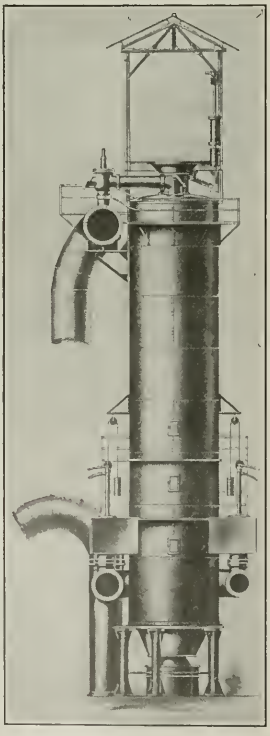
It may be assumed, without question, that uniformity in output presupposes a similar condition as regards input, and that the former cannot be safely predicated on variable conditions as regards the latter. Therefore, in addition to certain essential conditions, already indicated, we should specify stone of uniform size within prescribed limits, clean and free from dirt, and charged in predetermined quantities at regular intervals; close regulation of the draft, and quality of the exit gases and their temperature; also close attention to regulation of the temperature in the reaction zone.

[2]Geological Survey of Ohio Bulletins 4 and 5, Orton & Peppel.

For the purpose of description the kiln may be divided into three sections or zones, cooling, reaction and preheating. At the bottom of the cooling zone is located the continuous discharging mechanism, and at the top of the zone the inlet tuyeres, admitting the fuel gas from the producers to the reaction zone. The design of the tuyeres is important in order that a uniform distribution of the fuel gas may be insured throughout the mass in the reaction zone; otherwise, there would be a tendency for the gas to creep up the sides of the kiln, causing over-burning at the sides and under-burning or core in the center.

The reaction zone is encircled with three rows of peep-holes for observation. The couple of the recording pyrometer is located in the middle belt. The boundary line between the reaction and preheating zones is not, of course, very sharply defined, but it may be roughly assumed that the preheating zone is comprised within the limits of the upper half of the kiln, and the reaction zone the fourth next below.

Gas is admitted from the producers to the reaction zone through water-cooled balanced valves, easily regulated from the ground, where are located the temperature gages for each kiln. The continuous discharge mechanism at each kiln is driven from a common shaft, but can be stopped or started independently of the balance of the kilns in the battery. The speed of discharge is figured to 25 tons of lime per day of 24 hours, though means are provided for varying the speed of the common driving shaft. The top of the kiln is closed, and in the cover is located a hopper and charging belt, the latter raised and lowered by compressed air, and designed to give a uniform distribution of the stone over the top of the kiln, maintaining the surface level at all times, insuring an even distribution of the gases in the preheating zone. At the top of the kiln is also located the draft pipe for the exit gas, regulated by a valve of the same type as that used for the fuel gas.



GAS-FIRED CONTINUOUS KILN

The total height of the kiln to the level of the charging floor is 60 feet, and from the bottom of the cooling zone to the top of the preheating zone 48 feet. The diameter is 8 feet, maximum, inside the brick work. The stone is charged in uniform batches of 1000 pounds at regular intervals of 15 minutes, or 4 periods per hour, for a capacity of 25 tons per day. The draw is continuous, and can be arranged at any section of the bottom circumference where most convenient. The cold lime is removed in barrows or conveyors, for hydrating, storage, or direct to cars for shipment.

The preferred arrangement of the kilns is in batteries of six, with a producer-gas machine located midway of the battery. This combination, under proper control, will have a capacity of 150 tons of lime per day, with a coal to lime ratio of 1 to 5 or 6, depending on the quality of the coal. Four kilns of this type have been in constant service at the plant of the Farnam Cheshire Lime Company, Farnam, Mass., for a period of over five years, and are reported to have given satisfactory results in economy of operation, capacity and quality of product.

Roanoke, Va.

Strength of Commercial Liquid Glues

Most of the commercial liquid glues are manufactured from the skins, heads and swimming bladders of fish. Others are made by special treatment of the glue extracted from the hides, skins and bones of cattle; some for special uses are prepared from starch, from various natural gums, or from casein.

At the Forest Products Laboratory tests were made on a number of these liquid glues by B. A. P. inspectors, who found that they differ widely in strength. Some of them are so weak as to be entirely unsuitable for woodworking purposes, while others compare favorably in strength with the "hot" glues. The adhesive strength of the glues tested varied from less than 50 lb. per sq.in. to more than 3000 lb. per square inch.

Liquid glues may be tested by gluing together pairs of specially selected hard maple blocks, placing them in a testing machine, and measuring the force required to shear them apart. About 300 specimens, representing 26 different glues, have been tested in this way at the laboratory. According to the data thus obtained, a high grade liquid glue should have an average shearing strength of not less than 1700 or 1800 lb. per square inch.

In addition to uniform high adhesive strength, it is evident that certain other characteristics are desirable in a liquid glue. When spread upon wood surfaces, it should "set" and dry rapidly. In its container, it should remain fluid and workable at all ordinary temperatures. It should be elastic and shock-resistant. It should not be unusually susceptible to the action of high temperatures, high humidity, molds and bacteria.

The study gave evidence that the strength of liquid glue, like that of "hot" glue, depends largely upon its "body," or thickness, or, strictly speaking, upon its viscosity. Of 11 liquid glues examined, the thickest or most viscous glues showed the greatest adhesive strength.

German-Owned Shares Sold

The German-owned shares of the capital stock of the American Metal Co., Ltd., were sold at public auction by the Alien Property Custodian on April 7. Hayden, Stone & Co. of 25 Broadway, New York City, bought 36,344 shares for $4,850,160, while 562 shares of capital stock of the Compania de Minerales y Metals, a subsidiary company, were sold to Mr. H. W. McAnteer of the American Metal Co. for $57,000. Since none but American-owned companies were allowed to bid, 76 per cent of the stock is now in American hands.

Recent Chemical and Metallurgical Patents

Nitrogen Fixation

Nitrogen From Air.—Ammonia from cyanamide is combined with sulphur dioxide and water to give a concentrated solution of ammonium sulphite. When this is treated with air on the counter current principle, the oxygen converts the sulphite into sulphate, and by arranging the absorption towers in series, the oxygen is almost completely absorbed at a temperature of 70 to 75 deg. C. In this manner NOBILE TOMMASI of Basel, Switzerland, obtains a supply of pure nitrogen for the further production of cyanamide; 48.3 kilos of ammonium sulphite, containing 11.7 kilos of nitrogen, absorb 6.7 kilos of oxygen. The residual nitrogen, 22.4 kilos, is nearly twice that required to produce 48.3 kilos of ammonium sulphite additional, and is consequently sufficient to cover any losses in the manufacture of cyanamide, (1,295,635; Feb. 25, 1919; assigned to Usines Electriques de la Lonza of Gampel, Switzerland).

Separation of Alkali-Metal Cyanide From Hydroxide.—Alkali-metal cyanide made by passing nitrogen over a heated mixture of sodium or potassium carbonate and coke or charcoal is always contaminated with the oxide or hydroxide of the metal used. FLOYD J. METZGER of New York adds to this mixture sufficient water to convert any unchanged anhydrous carbonate into the decahydrate. A "treating solution" consisting of a water solution of ethyl, methyl or denatured alcohol, acetone or a similar solvent is used to dissolve the cyanide and hydroxide, the hydrated carbonate being insoluble in the mixture. By passing carbon dioxide into the resulting solution, the hydroxide is converted into carbonate, which separates out as the decahydrate. The filtered solution, after evaporation in a solvent recovery apparatus, yields pure alkali-metal cyanide in a dry state. (1,295,049; Feb. 18, 1919; assigned to Air Reduction Co.)

Ammonia From Alkali Cyanide and Ferrocyanide.—Cyanides are decomposed by steam according to the equation:

$$NaCN + 2H_2O = HCO_2Na + NH_3$$

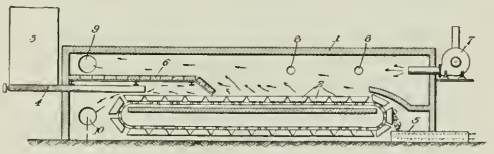
When, however, cyanide resulting from the process of fusing a carbonate with charcoal and iron is used, the yield of ammonia is poor. C. F. BIERBAUER of Kenvil and L. S. FINCH of Dover, N. J., dissolve the crude cyanide as rapidly as possible by blowing the powdered material into a tank equipped with a water spray and agitator. The solution is immediately filtered on a continuous rotary filter. In this manner the formation of ferrocyanide is reduced to a minimum. The solution is heated indirectly by steam at 125-lb. pressure in a tank provided with pressure relief valve which is set to operate at 50-lb. pressure. Pressure in the tank is thus maintained at 50 lb. while the ammonia and water vapors which pass through the relief valve are condensed, a portion of the water condensed being returned to the tank so that the final product is a concentrated ammonia solution. When the crude material contains an appreciable amount of ferrocyanide, the cyanide present is changed into ferrocyanide by digesting with finely divided iron, and the whole decomposed, after filtering, in a similar apparatus using from 80 to 150 lb. pressure. (It would seem as though the mixture could be treated without the conversion of cyanide to ferrocyanide, by first decomposing the cyanide at 50-lb. pressure and subsequently increasing the pressure by means of the relief valve, so that the ferrocyanide would be decomposed.) (1,295,262 and 1,295,293; assigned to the Hercules Powder Co.)

Nitric Acid From Ammonia.—Although ammonia will not burn in air even in the presence of a catalyzer, unless the latter is heated to from 600 to 700 deg. C., WALTER S. LANDIS of New York has found that with air so enriched as to contain 30 to 40 per cent oxygen, external heating of the catalyzers is unnecessary, and the reaction proceeds according to the equation:

$$4NH_3 + 5O_2 = 4NO + 6H_2O.$$

The nitric oxide is converted into nitric acid by known methods. The necessary oxygen may be obtained from liquid air, and the nitrogen used to make cyanamide as the source of ammonia. (1,292,814; Jan. 28, 1919; assigned to Frank S. Washburn.)

Manufacture of Calcium Carbide.—A method for producing aggregates to be used as the charge in calcium carbide furnaces was patented by FREDERICK M. BECKET of Niagara Falls on April 27, 1915 (1,137,567). Lime was mixed with bituminous coal and the aggregates formed in a by-product coke oven of the



METHOD OF PREPARING CHARGE FOR CALCIUM CARBIDE FURNACE

ordinary type. His present inventions deal with a special type of furnace, in which heat losses are reduced to a minimum by burning the limestone and coking the mixture in a single operation. The hot gases from the limestone give the heat necessary for the coking operation, while the volatile products from the latter, after passing through a by-product plant, are used as part of the fuel for burning the limestone. A mixture of $\frac{1}{8}$-in. grains of limestone and rich bituminous coal, in the approximate proportions of 100 to 62, is fed from the storage bin 3, by means of a mechanical device 4, into the cars 2, which form a continuous chain. The furnace is heated by the burners 7, 8, but during the first stage of the passage through the furnace, the material is protected from the direct action of the flame by apron 6. As a result, the coking operation is practically completed during this period, the volatile products escaping through opening 10, to be used as indicated above. In the open portion of the furnace, the limestone is converted into lime, without, however, injuring the aggregates already formed. The fully converted charge is conveyed, by means of 5, to the carbide furnaces with as little loss of heat as is practicable. (1,292,386 and 1,292,387; Jan. 21, 1919; assigned to Union Carbide Co.)

Hydrometallurgy of Copper.—Fig. 1 represents a flow sheet of a process devised by W. N. ROSSBERG and A. E. SHERIDAN of Butte, Mont., for the recovery of copper from sulphate solution. This solution should be free of considerable quantities of iron before entering the absorption tower. This may be done by air agitation with copper oxide and then filtering. Precipitation by H_2S as cuprous sulphide requires but half the amount of reagent necessary otherwise, and while effected at atmospheric temperature and pressure, is considerably facilitated at 160 deg. F. and 40 lb. per sq.in. The reactions are complicated and not determined; but may be summed to

$$2\ CuSO_4 + H_2SO_3 + H_2S + H_2O = Cu_2S + 3H_2SO_4$$

Thus acid is generated as well as recovered. The prepitation may also be effected by adding powdered CaS to a solution previously saturated by SO_2 as follows:

$$CaS + 2CuSO_4 + H_2SO_3 + H_2O = Cu_2S + CaSO_4 + 2H_2CO_4$$

which reaction is also facilitated by heat, pressure, agitation and free acid. The patentees point out that this process can be utilized to purify zinc sulphate

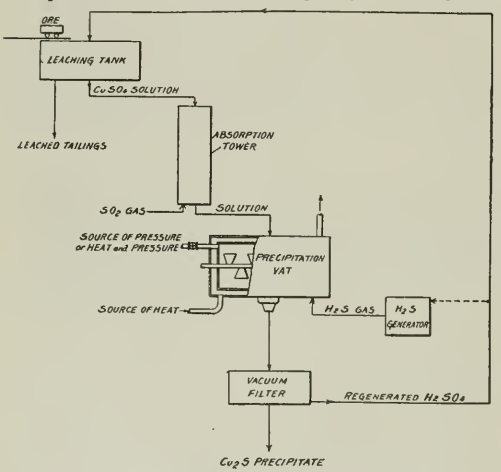


FIG. 1. FLOW SHEET OF PROCESS FOR RECOVERY OF COPPER FROM SULPHATE SOLUTION

solutions from metals of the second group. Its advantages are that it generates acid, requires a minimum of H_2S, gives a high-copper precipitate, and gives a final solution substantially free from H_2S, any excess being neutralized by the SO_2 present. (1,292,075; Jan. 21, 1919.)

Manganese Dioxide Depolarizers.—While pyrolusite, or natural manganese dioxide, is used as a depolarizer in large batteries of the Leclanché type, the artificial product is more efficient for small dry batteries, especially those used in flashlights. For the preparation of the latter, two reactions have been used:

$$Mn(NO_3)_2 + MnO_2 + 2NO_2 \qquad (170°\ C.)$$
$$2MnCO_3 + O_2 = 2MnO_2 + 2CO_2 \qquad (300°\ C.)$$

The low melting point of manganese nitrate causes the product of the first reaction to appear in the form of a hard solid mass, which, even after grinding, is inferior to the powdered mineral. The second reaction does not go to completion and the carbonate remaining impairs the shelf life of the cell. By combining the two methods, MORDUCH L. KAPLAN of Brooklyn overcomes these difficulties. Manganese carbonate is heated above 300 deg. C. for several hours, yielding a product containing approximately 70 per cent MnO_2. Treatment with nitric acid converts the unchanged carbonate and acid-soluble impurities into nitrates. The mixture is heated to the temperature at which the $Mn(NO_3)_2$ decomposes. The nitrates formed from the impurities are stable at this temperature and are removed from the final product by extraction with water. (1,293,461; Feb. 4, 1919.)

ALFRED A. WELLS of Montclair, N. J., prepares a carbide of manganese by heating pyrolusite and coke together in an electric furnace. The iron carbon formed simultaneously is not readily decomposed by water, while the Mn_3C is converted into a flocculent hydrate $(MnO_2H_2)_2$, which may be separated from the heavier undecomposed carbides by floating. Upon oxidizing the hydrate in aqueous suspension by ozone, or a mixture of air and ozone, a very efficient variety of manganese dioxide results, which is considered to be either a polymerized form, or a cyclic modification.

$$3MnO_2 + 7C = Mn_3C + 6CO$$
$$Mn_3C + 6H_2O = (MnO_2H_2)_3 + CH_4 + H_2$$
$$2(MnO_2H_2)_3 + 3O_2 = 2Mn_3O_8 + 6H_2O$$

(1,293, 272; Feb. 4, 1919; assigned, by mesne assignments, to National Carbon Co.)

By-Products From Iron Blast-Furnaces.—H. B. WEAVER and JAMES GAYLEY of New York note that volatile potassium cyanide and carbonate, together with a much smaller amount of sodium compounds, may be withdrawn from the bosh of an iron blast-furnace through suitable openings near the tuyere zone and condensed in quantities sufficient to make the process commercially feasible. The patentees think that these compounds are formed at the focus, and exist unchanged for a certain distance up the bosh in the hot reducing atmosphere, but there break up, and the basic portion is largely condensed and returned. In this manner, a zone of high-alkali volatiles exists, being continually renewed by the descending charge, and bled mostly by the formation of slag. It can, however, be abstracted either continuously or intermittently as noted, care being taken to withdraw a quantity of gas which carries less heat than the normal excess of hearth over shaft heat. This is controlled by frequent test slag-taps—dark slag immediately indicates improper working and slagging of iron due to excessive withdrawals of heated gas. (1,292,937; Jan. 28, 1919.)

Concentrating System.—RUDOLF GAHL of Denver, Colo., notes that in either water or flotation concentration the middling product is difficult to handle owing partly to the accumulation of altered or partly decomposed minerals. At other times tailings (particularly from flotation machines) contain considerable amounts of unrecoverable oxidized minerals. He therefore patents the process of producing a clean concentrate, then roasting the deslimed middling and leaching it by suitable reagents either alone or in conjunction with the tailings, and finally recovering valuable metals in solution by electrodeposition or otherwise. (1,291,824, Jan. 21, 1919.)

Synopsis of Recent Chemical and Metallurgical Literature

Metallurgical Practice.—H. L. CAMPBELL, metallurgist of the Industrial Works, Bay City, Mich., which specializes on locomotive cranes, has given a paper before the Steel Treating Research Society, which is published in their *Proceedings*. In it he presents the accompanying tabulation of physical and chemical properties specified for various crane parts, together with the directions for heat treatment.

TABLE I. PHYSICAL SPECIFICATIONS OF METALS

Material	Heat Treatment	Tensile Strength	Elastic Limit	Elongation per Cent.	Reduction, per Cent.	Sclerscope No.
Hammered steel, C 0.30 to 0.40 per cent	. .	65,000	30,000	36	52	22
Hammered steel, C 0.30 to 0.40 per cent	R.	90,000	60,000	25	50	30
Hammered steel, C 0.20 to 0.30 per cent	...	63,000	30,000	35	50	20
Hammered steel, C 0.20 to 0.30 per cent	R.	80,000	45,000	30	50	27
Hammered steel forged, C 0.20 to 0.35 per cent	R.	101,000	62,500	21	34	33
Hot rolled steel shafting, C 0.25 to 0.35 per cent	...	60,000	26,000	40	50	19
Hot rolled steel shafting, C 0.25 to 0.35 per cent	R.	65,000	35,000	35	55	22
Hot rolled steel rectangular bars, C 0.25 to 0.35 per cent	...	50,000	30,000	40	70	15
Hammered steel (forged aa keys), C 0.20 to 0.30 per cent	.	100,000	90,000	20	38	46
Trojan steel, C 0.40, Cr 1.00, Ni 2.00	...	120,000	95,000	18	50	30
Swedish iron	...	50,000	30,000	30	40	16
Wrought bar iron	...	50,000	26,000	32	35	17
Cold rolled steel (shafting)	...	82,000	73,000	20	45	28
Cold rolled steel (studs and bolts)	. .	85,000	75,000	18	35	30
Cold rolled steel (keys)	. .	80,000	70,000	22	50	27
Machine bolts (large size blank bolts)	.	65,000	35,000	30	40	20
Cast brass B21	...	20,000	16,000	5	5	12–14
Cast brass B21 compression	...	115,000	19,000			
Cast brass B27	...	25,000	18,000	10	10	14–16
Rolled brass (in stock)	...	56,700	47,000	30	45	36
Parsons' manganese bronze	...	65,000	30,000	25	25	.....
Cast vanadium steel (general castings other than beams)	P.	100,000	70,000	20	32	32
Cast vanadium steel (beams)	J.	100,000	65,000	20	35	32
Cast carbon steel	...	60,000	30,000	25	30	20
Cast carbon steel	E.	70,000	40,000	30	40	19
Cast carbon steel	F.	61,000	37,000	32	45	17
Cast carbon steel (gears)	K.	85,000	50,000	25	40	21
Cast carbon steel (gears with hard wearing surfaces)	R.	95,000	60,000	22	30	24
Cast carbon steel (rollers with very hard surfaces)	L.	100,000	70,000	15	25	30
Structural steel	.	60,000	38,000	28	54	24
Special brake band steel	.	95,000	60,000	12	20	35
Soft brake band steel	...	50,000	35,000	40	50	22
Stay bolt iron	...	49,000 53,000	24,500 26,500	30	48	.....
Gray cast iron	3,200 Pounds, transverse breaking load on 1½-in. bar with 12 in. between supports.					
Gray cast iron	20,000 Pounds, tensile strength per sq.in.					
Gray cast iron	100,000 Pounds, compressive strength per sq.in.					
12 per cent semi-steel	3,000 Pounds, transverse breaking load on 1-in. square bar with 12 in. between supports.					
12 per cent semi-steel	20,000 Pounds, tensile strength per sq. in.					
30 per cent semi-steel	3,500 Pounds, transverse breaking load on 1-in. square bar with 12 in. between supports.					
30 per cent semi-steel	30,000 Pounds, tensile strength per sq.in.					

TABLE II. CHEMICAL SPECIFICATIONS

	C	Si	Mn	S	P
Cast vanadium steel	0.30	0.27	0.80	<0.03	<0.05
Cast carbon steel	0.24 to 0.32	0.25 to 0.30	0.65 to 0.80	<0.08	<0.06
Gray cast iron	1.6 to 1.9	0.5 to 0.9	0.06 to 0.08		<0.50
12 per cent semi-steel	1.8 to 2.25	0.95 to 1.0	0.04 to 0.06		<0.50
30 per cent semi-steel	1.4 to 1.5	0.95 to 1.0		<0.05	<0.30

Heat treatments are as follows:

E. Heat to 1600 deg. F. and hold for 30 min.; cool in air for 10 min.; replace and cool in furnace, leaving door open until temperature is below 1300 deg. F. For mud rings, and door rings.

F. Heat to 1600 deg. F. and hold for 60 min.; cool in air to below red heat; reheat to 1250 deg. F. and hold for 90 min.; cool in furnace. For large castings to produce maximum softness with fine grain.

J. First heat: Heat to 1800 deg. F. and hold for 2 hr.; cool in air. Roughing cuts. Second heat: Heat to 1200 deg F. and hold for 3 hr., cool in furnace. Finish machining. For vanadium steel jack-beams.

P. Heat to 1800 deg. F. and hold for 60 min., cool in air to below red heat; reheat to 950 deg. F. and hold for 90 min., cool in furnace. For vanadium steel castings.

L. Heat to 1600 deg. F. and hold for 60 min.; quench in water and remove while warm; reheat to 750 deg. F. and hold for 90 min., cool in furnace. For roller pins and parts of maximum hardness.

K. Heat to 1600 deg. F. and hold for 60 min.; quench in oil and remove while warm; reheat to 900 deg. F. and hold for 90 min., cool in furnace. For gearing.

R. Heat to 1600 deg. F. and hold for 60 min., quench in water and remove while warm; reheat to 900 deg. F. and hold for 90 min., cool in furnace. For hammered or rolled shafting and castings.

This company makes its own alloy steel by addition to converter metal. Sixteen pounds of 35 per cent ferrovanadium and 18 lb. 80 per cent ferromanganese per ton of steel are preheated in the ladles; 10 lb. 50 per cent ferrosilicon is added during pouring from converter.

Rupture of Cast Iron in Contact With Mixed Acid.—In a paper read before the Edinburgh section of the Society of Chemical Industry, A. C. CUMMINGS of the Lothian Chemical Co., Ltd., called attention to the possible dangers arising from the use of cast-iron apparatus with nitric or fuming sulphuric acid. (*Journal* Soc. Chem. Ind., Feb. 15, 1919, p. 31T). In connection with the manufacture of TNT, this company used cast-iron acid eggs for handling the mixed acid, which consisted of 50 per cent nitric acid, 45 per cent of sulphuric acid and 5 per cent of water. About two years ago, two of these eggs burst while blowing was in progress, with serious results. The dimensions of the eggs were as follows, those of the second egg being in parentheses: Internal diameter, 4 ft. (6 ft.); depth, 4 ft. 9 in. (6 ft.); average thickness of walls, 1 in. (1½ in.). The air pressure was normally much lower than the maximum of 60 lb. per sq.in. In bursting, the egg appeared to fall in rather than to be blown out.

Examination of pieces of the iron showed that corrosion was practically negligible. Furthermore, the tensile strength of the iron from the inner surface was still equal to that of the original iron, consequently the egg should have been able to resist a pressure many times greater than that actually employed. However, on breaking a washed piece of the iron, the odor of acid was noticeable, and after two days the inner half of the fracture was badly rusted. Photomicrographs showed graphitic plates of large size which formed "nests" near the surface of the iron, making a coarse or open structure. As a result, acid had actually penetrated to a depth of about one-third of the thickness and in many places small masses of crystallized iron salts could be seen in the interior.

The action of fuming sulphuric acid on cast iron was observed by R. KNIETSCH (Ber., 1901, 34, 4090), who gives the following explanation:

"This remarkable phenomenon is caused by oleum diffusing into the pores of the cast iron, and there be-

ginning its work of destruction, inasmuch as it is converted into sulphur dioxide and hydrogen sulphide by the reducing action of the iron, and may even give rise to carbon dioxide from the carbon in the iron. All of these substances are gases with comparatively low critical temperature, and consequently cause high pressure in the interior of the cast iron. If such a piece of iron is broken, the presence of sulphur dioxide and hydrogen sulphide may be recognized by the smell and the evolution of gas when it is immersed in a suitable fluid."

MR. CUMMINGS' theory is that the disruption is due to the expansive force of the crystals of iron salts growing in the interior of the metal. Examination of some cast-iron measuring pots which had been used for mixed acids, but had never been under pressure, showed the presence of cracks of a similar nature. This would tend to substantiate the crystallization theory.

Regardless of theory, the fact remains that the penetration of the acid into the surface of the casting is the initial factor in the disruption of the apparatus. It would thus appear that the aim of manufacturers of cast-iron apparatus for use with nitric or fuming sulphuric acid should be to avoid as far as possible an open structure which would permit the acid to penetrate into the interior of the iron.

Purifying Paraffine Wax.—In the *Engineer*, Feb. 14, 1919, a description is given of a process devised by R. S. DICKIE, which is an improvement on the sweating process for refining paraffine. It is applicable to hard, middle or soft scale, or a mixture of all three. The material to be treated is melted at as low a temperature as possible and is then pumped through a spraying nozzle, in which a blast of cold air atomizes and at the same time chills the scale. The temperature of the material issuing from the nozzle is 5 to 10 deg. F. below the melting point of the scale. At this temperature, the particles of wax solidify, while the oil and low melting point paraffines remain liquid. The atomized mass passes into a rapidly revolving drum formed of fine mesh wire cloth. The liquid portion of the mass is separated from the yellow wax by centrifugal force, and is collected in an annular trough surrounding the drum. From one to three minutes suffices for the separation of the heavy oil. The residue of yellow wax is removed by heating the drum electrically to 140 deg. F., the melted wax being collected in a second annular trough.

Specific Heats of Silicates and Platinum.—WALTER P. WHITE of the Geophysical Laboratory has published a second series of specific heats of silicates in the *American Journal of Science*, 47, 1 (1919), and also a determination of the specific heat of platinum at high temperatures, using the same apparatus, in the *Physical Review*, 12, 436 (1918). The results for platinum up to 1300 deg. C. are thought to be accurate to within 3 per mille, and the increase of the specific heat at constant pressure with rise in temperature is so nearly linear that the following equations hold:

True specific heat $= 0.031686 + 0.000064$ deg. C.

Atomic heat, $A_p = 6.185 + 0.00125$ deg. C.

There is no reason to suppose that this specific heat at constant pressure really varies linearly, since the work of expansion does not; yet it gives a simple expression well within the accuracy of the experimental data. The specific heat at constant volume cannot be determined experimentally, but may be calculated from the values for constant pressure. The figures for several temperatures are as follows:

Deg.	A_v
500	6.447
900	6.678
1300	6.844

It will be noticed that A_v increases regularly with advancing temperature and, also, that it is above the value 5.96 indicated by the accepted kinetic theories of the solid state and Delong and Petit's law (as modified by G. N. Lewis *et al.*).

Micrometer With Pressure Attachment

A CONVENIENT instrument for testing the properties of rubber, felts, etc., used for packing, gaskets and various compressibles has recently been put on the market by S. W. Widney of Chicago.

The resiliometer is, in effect, the combination of a direct reading dial type micrometer gage with a reaction device whereby both the compressibility and the rebound after compression (otherwise known as the resilience) of the material can be determined positively. The readings are simple, and therefore easily understood.

The resiliometer gives the following information in direct readings:

Thickness (normal), in thousandths of an inch (first standardized method).

Hardness, i.e., the precise extent to which a material gives as the result of a standard pressure (first standardized method).

Resilience, i.e., the rebound—the capacity to recover from compression after the load is released. Resilience is a quality not fully understood by many large users of felt, rubber, leather, paper, cork, textiles and other compressible materials, as not infrequently the resilience is estimated in excess of the load applied. This is impossible because compression, while it may destroy energy, cannot create it. Therefore, the maximum resilience is the amount of the load.

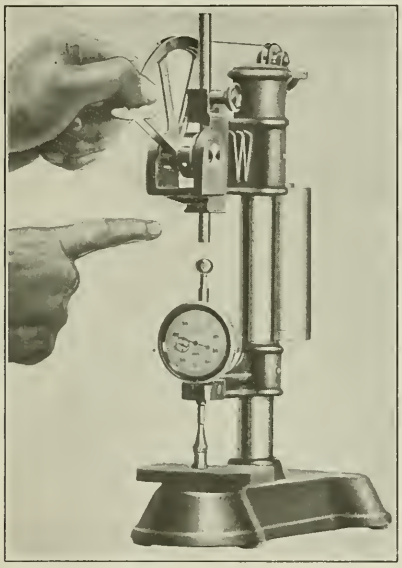
As will be seen by a glance at the illustration, the instrument consists primarily of a dial underneath which is a presser-foot touching a perfectly level base on which the material is supported. Making sure that the quadrant which holds the weight descending from it is drawn up and held by the spring-catch, the operator lifts up the presser-foot and inserts the material which is to be gaged and tested.

The large dial is graduated in 100 divisions of 1/1000 in., so that one revolution of the large pointer or hand is equivalent to an elevation of 0.1 in. To count tenth-inch increments a small dial indicates the number of revolutions of the counter or hand. Suppose the material to be tested is 0.100 in. thick, then as the presser-foot goes down, the hand stops at the 100th gradation.

Release the spring-catch holding the weight and allow the weight quadrant to swing back until pressure is put on upper end of presser-foot at the top of dial. As weight is released, the plunger, which is connected with the quadrant, forces the presser-foot to sink into the material, thereby diminishing its thickness. When the presser-foot reaches the limit of compression with the weight applied, the reading on the dial at that time is taken and compared with the normal or original reading. For instance:

Normal thickness reading.....	0.100 in.
Reading under pressure.....	0.050 in.

These readings are interpreted that goods of a normal thickness of 0.100 in, showing under pressure a thickness of 0.050 in., are 50/100 hard. The material is arbitrarily called 50 per cent hard. If it had not been compressed at all its hardness would have been 100 per cent (an impossibility with any resilient material). If it had compressed to one-fourth its original thickness, its hardness would have been 25 per cent. If it had compressed to one-tenth of its original thickness, it would



MICROMETER WITH PRESSURE ATTACHMENT

have been 10 per cent hard, and so on. This gives us the hardness figure of the material in question—a figure henceforth fixed in comformity with the Widney standard.

As soon as the reading has been taken, pull the quadrant back, releasing weight pressure on the presser-foot. The hand on the dial will begin to advance again. When weight is raised a sufficient height so that the weight pressure is released from the presser-foot, immediately note the reading of the dial hand. This reading should be taken as weight pressure is released, thereby ascertaining the instant comeback or rebound and not the gradual return.

For example if the dial-hand (which was at 50 under pressure) advances as pressure is released till it reached 0.080 in., the rebound is 60 per cent. For 80 — 50 = 30 and 30 is $\frac{3}{5}$ of 50 = 60 per cent. Had the material tested immediately resumed its original thickness, the rebound would then be 100 per cent. The ratio of the distance of rebound to the distance of compression is the percentage of rebound.

The capacity of a material to rebound after the load is released is often confused with the resilience. However, a distant rebound is not the true measure of resilience. Bear in mind that resilience is the capacity which the material has for giving back energy given it during the loading process. The only existing means of ascertaining the amount of this energy is by the resiliometer method—applying successive increments of load, plotting the increment line, and removing the load in successive decrements, plotting the decrement line. Between these two lines is the hysteresis or energy load. The area back of the line indicates the amount of energy recovered after the load is released.

Resilience also is sometimes confused with elasticity, which is the capacity of material to distend or reflect, as illustrated by the action of a rubber band after being stretched beyond its normal position or the reaction of a steel bar after being bent out of its original or normal position.

Logically, the resilience of any compressible material is determined by its capacity to recover from compression after the load is removed.

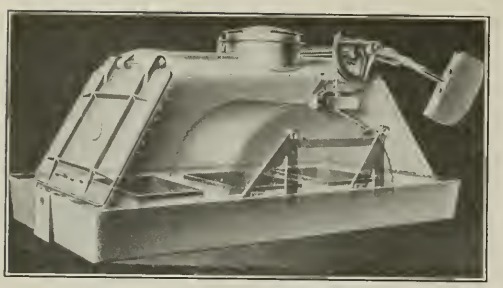
Gas Reversing Valve

IN THE operation of any gas-fired furnace, it is highly desirable that the valve controlling the direction of the flow of gas shall operate rapidly and easily. These factors have been kept in mind in designing the new W-S-M gas reversing valve which has just been placed upon the market by the Wellman-Seaver-Morgan Co. of Cleveland, Ohio. That the conditions have been met is evidenced by the fact that a 36-in. hand-operated valve can be reversed in from 3 to 7½ sec. with a pressure of not more than 25 lb. This is accomplished by a balanced hood and counterweights. An equally important feature is that the operating mechanism is outside of the casing, where it is easily accessible and always cool.

The center port is connected to the chimney. Waste gases from the furnace flow from whichever outside port the hood is covering to the chimney port. This leaves a clear passage for the fuel gas or the air entering the casing through the mushroom valve at the top to pass through the third port to the furnace regenerator. Reversal of the flow of gas or air is accomplished by moving the hood to a position over the center port and the one previously uncovered.

The base of the valve is a cast iron rectangular pan with three walled circular openings or ports. The hood which covers the center and one end port is semi-elliptic in form and made of steel plates with angles at the bottom to support a fire-brick lining. The base pan holds a quantity of water so that when the hood is over the ports a water seal is formed to prevent the escape of gas. The base pan has a tapped hole at each end for a water pipe. There is a perforated strainer at the intake end and a dam plate at the other end to hold the water at such level as to allow the hood to extend 3 in. into the water forming the seal.

The outer casing is made of steel plate and lined with fire brick. It has cast iron door frames and door at each end through which the hood may be removed or inserted. Each door has a small peekhole with a swinging cover which enables inspection at any time. On the top of the casing is a cast iron neck which connects either with the fuel gas flue or the air intake, depending upon the purpose for which the valve is used. The hood is moved by a series of levers and coupling shafts which extend through the water under the casing and into sockets on the hood. The shafts move on chilled iron bearings. The following advantages are claimed for this valve:



NEW DESIGN OF A GAS REVERSING VALVE

The semi-elliptical form of the hood allows free flow of the gas, as there are no abrupt turns or constricted areas in the passage formed by the ports and hood. This feature is very important in obtaining maximum efficiency from the stack draft.

All leakage or waste of gas is prevented by the water seal. Such a seal does away with all packing, tightening and adjusting, the only attention required being the flow of a small quantity of water into the bed plate to replace the amount evaporated.

Due to its compactness, the valve requires comparatively little floor space and adapts itself to various arrangements of flues from the regenerators to the stack.

The weight of the hood is counterbalanced by the weights of the lever arm in such a way that the hood is in balance at any position, so to move the hood it is only necessary to exert enough force to overcome friction. This is an important feature in hand-operated valves.

New Type of Portable Arc Welder

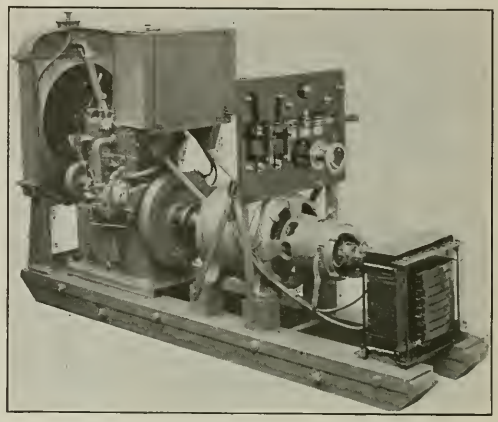
ALTHOUGH electric arc welding has been used for several years in the iron and steel industry, its use has mostly been confined to factories, repair shops and other locations where the work can be brought to the machine. The accompanying illustration, however, shows a new type of portable arc welder, which presents especially interesting features and is designed for operation where electric current is not available.

It consists of a Lincoln Electric Co. 150-amp. arc welding generator direct connected to a Winton G. L. 5-gasoline engine, and is intended for mounting on an automobile truck or other convenient position so that it may be transferred from place to place. An interesting point in its construction is the method adopted to insure a steady arc and a constant and readily controllable heat—the two greatest difficulties met with in the design of this class of apparatus.

The volts required to maintain a welding arc vary from 50 down to as low as 15 volts (where a metal electrode is used). The plan adopted by most makers to render the arc steady is to introduce sufficient "ballast resistance" in series with the arc to prevent excessive current being taken when the operator short-circuits the generator on "striking the arc." This method is exceedingly wasteful, more than three-quarters of the power generated being absorbed in the ballast resistance itself.

This arc welder uses a compound-wound generator, the series windings of which are connected up so as to oppose the shunt field, and the two windings are so proportioned that the voltage decreases in the same ratio as the current increases, thus limiting the short circuit current. Another important effect of this is that the horsepower, and therefore the heat, developed for a given setting of the regulator switch (shown on the control board above the generator) remains practically constant.

It is asserted that a kilowatt-hour can be made to do four or five times as much work with this



PORTABLE ELECTRIC ARC WELDER

welder than with machines using ballast resistance. Additional arc stability is also insured by the stabilizer (seen at the extreme right of the picture). This is a highly inductive low resistance coil connected in the welding circuit. It serves to correct momentary fluctuations of current in much the same manner as the flywheel of an engine produces an even turning speed.

Pyrometer for Brass and Bronze

THE importance of the pouring temperatures in the manufacture of brass and bronze castings is so well recognized that comment on that fact is hardly necessary. Wrong temperatures are probably the chief cause of faulty castings. This factor not only enters into the production of the casting itself, but the properties of the finished article are also affected.

The chief difficulty of measuring the temperature by use of the ordinary thermo-electric pyrometer has been the lack of a suitable protection tube for the thermocouple. There is a limit to the thickness of the tube wall which is permissible because of the necessity of a quick reading. The tube has to be of relatively thin walls, but at the same time it must successfully withstand the action of the molten material. Refractory tubes are not satisfactory because they are too fragile to stand ordinary foundry use, and are very apt to break under the sudden temperature changes encountered.

An alloy has been developed, however, by the Hoskins Manufacturing Co., Detroit, Mich., from which a satisfactory protection tube can be made. Fig. 1 illustrates how the equipment is used. The tube consists of three parts, as shown in Fig. 2. Section *B* telescopes into the upper end of the seamless steel tube *D*, and the

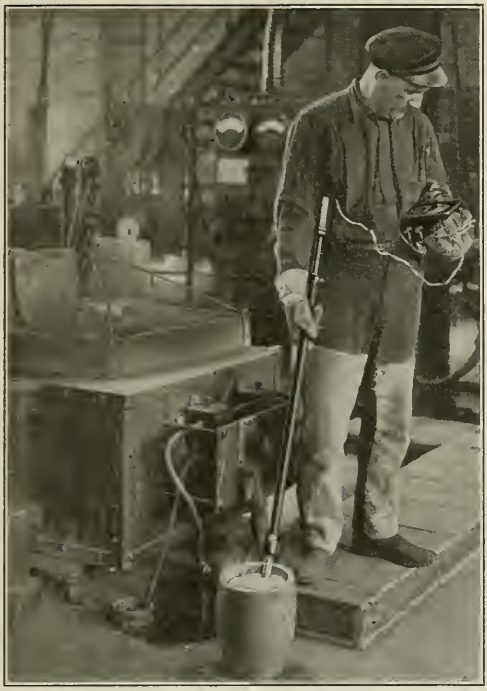


FIG. 1. READING THE PYROMETER

protection tube proper, marked *C*, is held in the lower end. This tube is 10 in. long and is made of the new alloy chromon; it is that part of the entire tube which is inserted into the metal. The thermocouple *A* is entirely encased in the tube and can be easily renewed.

The alloy tip and the thermocouple are the only parts which require renewal. When the molten metal ultimately destroys the alloy tube, it can readily be removed and a new one installed. A shoulder is cast on the upper end of the tip and this engages in the collar shown on the tube *D*, being held in place by giving it a half turn and packing the connection with a special refractory cement.

If the tube is used to complete destruction or to a point where the molten metal can reach the thermocouple, of course the latter has to be repaired. This can be done by merely cutting off the damaged part, and then twist and re-weld the wires. This procedure can be repeated until the couple reaches a length of 3½ ft., when it must be renewed. The couple can be changed end for end; that is, the unwelded end can be welded and used as the hot end. It is not necessary to re-calibrate the couple after re-welding it.

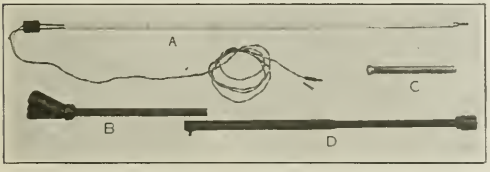


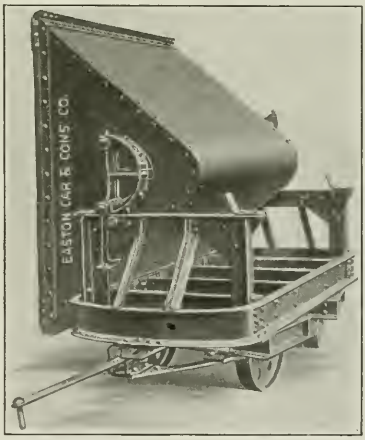
FIG. 2. PYROMETER FOR BRASS AND BRONZE

Trackless Trailer With Dump Car Body

THE increasing use of industrial tractors has created an unusual demand for all kinds of trailers. To meet the demand for a car that would not only admit of easy trailing but would also speed up loading and unloading of loose materials the new Easton car here shown was developed.

It is a four-wheel steer trailer that will run over cement, wood, composition or any kind of flooring. In fact, it will even run quite smoothly over rough ground when supplied with extra large wheels. All wheels are equipped with roller bearings and may be furnished with rubber or composition tires. Close tracking of trains of these cars is accomplished with comparative ease because both front and rear trucks of each trailer swivel. Trains of six cars will track within three inches and will take a curve of 8-ft. radius or smaller.

The body of the trailer is distinctive and possesses many features that make for economy and speed in loading and unloading coal, ashes, sand, ore, slag,



TRACKLESS TRAILER WITH DUMP CAR BODY

refuse and practically every kind of bulk material. Some of the more important features include: Special latch for locking the body in a half-dumped position, thus lowering the loading height for hand loading; automatic safety latches; extra heavy body that dumps clear of the wheels, the only type that will so dump (45 deg. angle of dump); cast-steel rockers and extra heavy underframes.

The car is built by the Easton Car & Construction Co. of Easton, Pa.

Italian Import Restrictions

The following commodities may now be imported into Italy by private importers when import licenses have been obtained covering such shipments. Formerly these commodities were among those which private importers might not import into Italy: Acetate of lime; acetone; alcohol; benzol; toluol; naphthaline; vegetable and animal tallow; leather; jute; wool, and cotton linters.

Book Reviews

A HANDBOOK OF PHYSICAL MEASUREMENTS. By *Ervin S. Ferry*. Two volumes. Price $2.00 each; 234 pages, including the index; illus. New York: John Wiley & Sons, Inc.

The author of this work has followed the plan of presenting at length the theory of the experiments and the derivation of the formulæ required in each division of the subject before giving descriptions of apparatus to be used and directions for the actual manipulations necessary in performing the experiments. The exposition of the theory is as brief and concise as is consistent with the author's purpose as indicated by his statement, "It is rare that an experiment should be performed before the student understands the theory involved and the derivation of the desired formulæ."

The first volume contains three chapters, the first being an introductory chapter upon physical measurements in general. Chapter 2, after a discussion of the theory and methods of fundamental measurements, gives detailed directions for 25 experiments upon the properties of matter. Most of these are standard in college laboratories, although several are somewhat novel, notably the last two, for determining liquid viscosity. The third chapter, occupying over half of the first volume, gives the theory and directions for 25 experiments in optics. Of these, several are unusual in a college or engineering course, particularly those which employ the spectrograph, spectrophotometer, colorimeter and polarimeter.

Vol. II contains four chapters, the first including 4 experiments upon vibratory motion, the second 10 in sound, the third 20 in heat, the fourth 24 in electricity and magnetism. Among these experiments are several usually performed in courses more advanced than those in general physics as given in most colleges or engineering schools. The author, while he states that some of these would be performed only by students specializing in physics, evidently believes that these more difficult experiments rightfully belong among those performed by the student during the time occupied by him in laying foundation for later more technical scientific knowledge. With this in view, the writer of this review fully agrees.

On the whole this manual is on a considerably higher plane than most of its kind.

THE PRINCIPLES, OPERATION AND PRODUCTS OF THE BLAST-FURNACE. By *J. E. Johnson, Jr.* 552 pages, illus.; price $5.00. McGraw-Hill Book Co., Inc.

This is the companion volume to the same author's "Blast-Furnace Construction in America." Together the two volumes form the most comprehensive treatise in any language on the subject of the iron blast-furnace, upon which J. E. Johnson, Jr., by virtue of his education and long practical experience, was an established authority. In the first six chapters of the book are discussed the chemical, thermal and mechanical principles in a manner which has the rare combination of being both exhaustive and clear. Of the chemical principles, Sir Lowthian Bell will long be remembered as the original and greatest expounder, while Johnson was likewise recognized as the exponent of the now generally accepted thermal theory, involving a critical temperature and available heat in excess of that temperature—a theory which had to win its way to a position of authority against the conservatism of many a learned professor, especially of the German school.

More than one-half of the book is devoted to the application of these several principles under the head of "Operation," in which place are treated the ascending column of gases and descending column of solid materials, slag, burdening, rate of driving, handling the furnace, irregularities and their treatment, and the combustion of gas. One notices a weakness in the lack of specific directions as to the application of some of the principles; for example, in no place do we find instructions as to the difference in practice when making foundry pig iron, ferromanganese and ferrosilicon. Truly the general principles are laid down with force and clarity, so that any capable and intelligent man can apply them and obtain the answer for himself, but for students and those who prefer to have others do their thinking for them, the classified repetition would be welcome.

Under the head of "Products" the author gives a good, scientific, although brief, account of the various commercial forms of pig iron, the effect of different elements, and the principles governing these effects. It will be remembered that Johnson was the first to publish (*American Machinist*, April 5, 1900, page 317) the theory of steel and cast iron as a continuous series of alloys of iron and carbon. The argument and the information given to practical foundrymen in this book are good; the micrographs are excellent and bring out well the points they illustrate.

The book closes with a valuable, thoughtful section on "Commercial Considerations and the Future Possibilities." There is an index, which is too perfunctory in character and limited in scope.

EXPLAINING THE BRITISHERS. By *Frederic William Wile*. Price $0.85, 118 pages, illus. Published Autumn, 1918. London: William Heinemann.

One of the most important things accomplished by the war was the establishment of more intimate and friendly relations among individuals of the allied nations. The American, for example, discovered the Britisher, and found, possibly to his surprise and certainly to his pleasure, that the latter was quite as natural and interesting a human being as his descendants in America. The book under consideration was written by an American for the purpose of explaining to the members of the American Expeditionary Forces some of the little peculiarities of our British friends. It was also designed to give the American and any one else who will read it a clearer idea of Great Britain's contribution to the war, dispelling the crude notion that England was not playing the game to the limit. Although written before the armistice was declared and primarily to predispose American troops favorably toward their brothers in arms, the book will have a permanent value in creating the proper spirit among members of the English-speaking races. It is written in the agreeable style of a versatile newspaper writer and presents facts and figures in an easy manner. It can be read with pleasure by every good American and with profit by any one who has been inclined to give ear to anti-British propaganda.

THE APPLICATIONS OF ELECTROLYSIS IN CHEMICAL INDUSTRY. By *A. J. Hale*. ix + 148 pages, illus. Cloth. Price $2.50 net. New York: Longmans Green & Co., 1918.

This book is one of the Monographs on Industrial Chemistry edited by Sir Edward Thorpe. It consists of an introduction and eight chapters. The introduction gives an account of the general principles of electrolysis and an explanation of electrochemical terms. The chapters have the following headings: Methods of Generating the Current; The Electrolytic Refining of Metals; The Electrolytic Winning of Metals; Electrolytic Production of Hydrogen and Oxygen; Chlorine and Caustic Soda; Hypochlorites, Chlorates, Perchlorates; Production of Inorganic Compounds.

This work is principally a description of the important electrochemical industries, is very readable and is on the whole a good introduction to the subject. The paper and print are excellent and the book has a pleasing appearance.

As it is the unpleasant duty of the reviewer to point out inaccuracies or omissions, the following must be mentioned. In the introduction, the inaccurate statement is made that when copper sulphate is electrolyzed between copper plates there is no back e.m.f. of polarization. In the chapter on methods of generating current, it is stated that lead storage battery plates are generally formed by the old Planté method of alternate charging in opposite directions. On the same page, the reactions at the plates are represented as occurring in two steps, involving loss of free energy cor-

responding to the reaction $PhO + H_2SO_4 = PhSO_2 + H_2O$, which loss does not occur. In the refining of metals, the explanation of why anode impurities behave differently is not given, and in describing the series system, it does not explain how the pure copper is separated from the undissolved impure copper. Other similar points might be mentioned. In the chapter on the winning of metals, nothing is said of the important process for producing copper used at Chuquicamata, Chile, and of similar work in the United States. Finally, the Darling process is incorrectly stated to be regarded favorably in America, while it has never been a success.

TREATISE ON APPLIED ANALYTICAL CHEMISTRY. By *Prof. Vittorio Villavecchia*, Director of the Chemical Laboratories of the Italian Customs, translated by *Thomas H. Pope*, B. Sc., A. C. G. I., F. I. C., University of Birmingham. 1918. Vol. II. Price $6.00. 536 pages, 105 illus. Philadelphia: P. Blackiston's Son & Co.

The first volume of this work was reviewed in our Vol. xviii, p. 488. This, the second volume, contains a good treatise on analytical chemistry applied to foodstuffs such as meat, milk, flour and beverages, and to some additional industrial products such as essential oils, varnishes, inks, leather and coloring matters. In wine and spirits we shall have at least an academic interest hereafter, and we will find much information here. Essential oils are well treated. Rubber, which was noticed by the reviewer as being absent from the first volume, is fairly well discussed.

It is curious to observe how the author's tastes or experiences are indicated by the relative amount of text under each head. Milk and its products occupy 22 pages; flour and derived products, 30 pages; sugar, 77 pages; varnishes, 7 pages; inks, 5 pages; leather, 9 pages.

Among industrial or food substances which might have been treated but are not found in these volumes are glass, clays for ceramic and refractory materials, paper and cardboard, explosives. The discussion of textile fibers as well as fabrics, of tests of their waterproofing, quality of methods for determining the weighting of silk, degumming, etc., as well as identification tables for coloring matters, make a particularly thorough chapter. Each one of these reviews of analytical methods is closed by a critical digest of the subject with emphasis upon the best criteria to rely upon. This is a good feature.

The cuts on prepared paper are good; the remaining cuts in many cases crude in drawing and poorly printed.

GAS AND FLAME IN MODERN WARFARE. By *Major S. J. M. Auld*, Royal Berkshire Regiment. Price $1.35. New York: Geo. H. Doran Co.

Shortly after the United States entered the war there was a great commotion about gas, and yet nobody seemed to know much about it. At least, only a few persons did. Of the vast majority, some knew a little, and were as secret as comic opera conspirators about it; others knew more—that is, they knew parts of more, but not the whole of anything. There was, however, one person among the few who was abundantly informed, who had had large experience, and who had a clear notion of what might be told and what might not. He was a strenuous worker in getting production started, a man of amazing ubiquity, approachable, affable, and keen as a whistle. It is not surprising, therefore, that when inquiries were made about this new method of warfare, the usual answer was, "See Major Auld if you can; he knows all about it." It is not of record that he ever overstepped the mark, or gave out information that would be of value to the enemy.

The gentleman was Major, now Colonel, S. J. M. Auld, sent here by the British at the request of the U. S. Government to aid us in those preparations for gas warfare which finally helped to take the heart out of Fritz and to impress upon no less a person than the great Von Ludendorff himself that there was something wrong about that last German "victory" drive. Colonel Auld is a chemist of parts; he wears the Military Cross for crawling into enemy trenches to observe the effect of a British gas attack, and he has been wounded in battle. A good soldier, and, as we should say, a live wire. He was in the trenches opposite Messines in April, 1915, when the Germans launched their first gas attack, and he was in the thick of the business from that time until the end of the war. His book, "Gas and Flame," tells the story very much as one would expect him to talk to a favored group of men sitting about a cosy fire in a pleasant club. It was designed for the general public rather than technical men, nevertheless the facts as to gases and what they are, are duly set forth.

The onus of introducing gas to the German military authorities and persuading them to use it he lays at the door of Professors Nernst and Haber. Nernst was one of the most arrogant pan-Germans and Anglophobes, and was made a Count (Graf) by the Kaiser for his "distinguished services." Long before the war started Haber and his assistants were known to have been working on poisonous arsenical gases and liquids. Haber also directed operations in the field. The first respirators, the helmets, and the joys and sorrows of drilling men to use them, are all described with the art of a good réconteur. And a great deal of incidental information is given for valid reasons. Of course the direction and speed of the wind in cloud attacks were matters of first importance, and "Beaufort's Scale," as it is called, devised long ago by a British Admiral of that name, was occasionally called upon when instruments were lacking. It is worth remembering:

"If smoke moves straight up, the speed of the wind is nil; if smoke slants, the speed is two miles an hour; wind felt on the face indicates five miles an hour; if paper and the like move about, the speed is ten miles; when bushes are seen to sway, it is fifteen; if tree tops sway and wavelets are formed on the water, it is twenty; and if treetops sway and whistle, it is thirty miles an hour."

The book follows the course of the war until it was written—which was before the armistice was signed. The interest never flags, and good stories abound from start to finish. The last chapter on Flammenwerfer shows the limitations of this method of warfare. There isn't much chance for the man that directs the flame, and it is only in surprises at very close quarters that he can accomplish anything with it.

GENERAL LECTURES ON ELECTRICAL ENGINEERING. By *Charles Proteus Steinmetz*. Fifth edition, compiled and edited by J. L. Hayden, 242 pages, illustrated; price $2.50. New York: McGraw-Hill Book Co., Inc.

So many material changes have taken place during the eight years since the earlier editions of these lectures were published that the author has entirely rewritten large parts of the previous editions and has made material changes and additions to some of the other parts.

These eighteen lectures deal with the generation, transmission, control, distribution and utilization of electric energy. They are written in the lucid, logical, easily understood style, with no waste of words, for which this author is so well known and which always assures him a large attendance at his lectures in various cities. After listening to one of these, no matter on what subject, one always feels that he has learned something or has learned to look at problems in a new or more logical and rational way; the well known and brilliant work done by the author also gives one the assurance that what he says is so, and that his conclusions reached in controversial subjects are the results of a logical, impartial and highly intellectual treatment by one who is exceptionally well posted and has had a vast amount of practical experience.

In the present volume the treatment is of this kind; the lectures are written in easily understood style, essentially descriptive and not mathematical or highly technical. No space is wasted in long historical descriptions of the many things which have been abandoned and superseded; indeed, one of the most valuable features of these lectures is that he gives the conclusions which have been reached as to what is considered the best and the standard practice of to-day, as also the reasons which have led to these conclusions. Another valuable feature is the discussion of the relative advantages and disadvantages of different apparatus and methods, which determine the best choice under different conditions.

Unlike the custom in so many books the author does not begin with "Adam and Eve" but assumes a general familiarity with the subject of electrical engineering, but on the other hand the style is such that no expert knowledge of the subjects is necessary to understand his treatment of them; highly mathematical discussions are almost completely absent.

The subjects of this collection of lectures are: General review; general distribution; light and power distribution; load factor and cost of power; long distance transmission; higher harmonies of the generator wave; high frequency oscillations, surges and impulses; generation; hunting of synchronous machines; regulation and control; lightning protection; electric railway; electric railway motor characteristics; alternating-current railway motors; electrochemistry; the incandescent lamp; arc lighting; modern power generation and distribution. The numerous methods of distribution, with the economy of copper conductors and their other advantages and disadvantages, are very clearly explained with simple diagrams. In discussing the cost of power, he adds to the usual two factors of fixed cost and a cost proportional to the power a third one, depending on the reliability of service required, which embraces the reserve. The discussion of the generation of the power, by water, steam engine, steam turbine and gas engine, is logical and instructive. Quite a long lecture is on the alternating-current railway motor. The lecture on electrochemistry is quite brief, dealing only with a few fundamentals, and from the practical standpoint. In the eighteenth lecture he expresses the opinion that at least for a long time to come there is very little probability that any form of internal combustion engine will even approach the efficiency of the steam turbine, which he considers has become and will remain for some time the "next feature"—the universal source of primary power.

His statement that "electricity is the most useless form of energy . . . and finds no industrial use as electrical energy" is one of those statements that startle one at first, until he explains that to be useful it is always converted into some other form of energy, such as light, mechanical energy, chemical energy, heat, etc., it being the connecting link between the original energy and its final useful form. He shows that with regard to energy, electrical transmission becomes what the railway system is with regard to the transmission of materials.

The volume concludes with an abstract of a recent lecture before the Franklin Institute, and a table giving the reactances for overhead lines.

THE FLOTATION PROCESS. By *Herbert A. Megraw*, 6 x 9, 359 pages, illustrated. Second edition, revised and enlarged. New York: McGraw-Hill Book Co.

The second edition of Megraw's book is a commentary upon flotation in more ways than one. It is both a good book and a poor book at the same time, for even after much excellent reading matter has been added it yet remains mainly a compilation. While Mr. Megraw has written an excellent introduction to the study of flotation for use of a technical student or an operator just taking up this process, the second edition will be found as disappointing as the first by the man who has been doing the actual work and has made it a rule to follow flotation literature as it has appeared.

Unfortunately, investigators, superintendents and managers generally can find little time, official encouragement or energy to write upon the subject they understand so well. It seems therefore inevitable that our technical books shall be written by students of an art rather than real practitioners. Even this state of affairs has certain compensation, since the author can generally draw upon the personal experiences and observations of the leaders in that art freely. Thus it is that our modern technical books show such general excellence.

In the main, Mr. Megraw has had to labor without such aid. He has visited many mills, and read extensively upon his subject. His condensations of his readings are excellent, and he has compiled with judgment. He is therefore not to blame for the shortcomings of his book. He had a right to expect that by this time flotation under the virile leadership of American engineers would have thrown off the yoke of Minerals Separation. In certain clauses of its licenses Minerals Separation strictly forbade all publication or dissemination of knowledge in regard to the art of those using its process, and in addition it claimed ownership of any new discoveries in the general art of flotation made while using its process. For years it succeeded in preventing the publication of many articles dealing with froth-flotation in Australia and in England, and as a result the process never advanced as it should until it was introduced into the United States. Here engineers, metallurgists and editors have largely refused to submit to such dictation, and as a result there has been more real advancement in the last four years than ever before. This advancement has been not because of Minerals Separation but in spite of Minerals Separation. Among editors Mr. T. A. Rickard deserves especial praise for the fearless way in which he has exposed all attempts to prevent the dissemination of technical knowledge even upon flotation. Among mining companies the industry owes gratitude to both Miami and Butte & Superior for the costly fight which they have made against the monopoly.

While other patentees have perverted our patent-law system to their advantage by various clauses in their licenses regarding use, sale and prices, the reviewer believes none has heretofore had the effrontery to try to use rights acquired under an "Act to Promote the Progress of the Useful Arts" to the direct, malicious purpose of preventing the spread of knowledge in that art.

Until that time when flotation has thrown off this clutch we must expect all books upon flotation to be mainly compilations of the writing of those fearless practitioners who righteously tell Minerals Separation to go to, and in public spirit give to the industry the benefit of their observations. Mr. Megraw therefore is to be praised for his public-spirited preparation of a second edition of his book.

Personal

PROF. COMFORT A. ADAMS, who is president of the American Institute of Electrical Engineers and was recently elected president of the American Welding Society, has been chosen dean of the faculty of the Harvard School of Engineering at Cambridge, Mass.

PROF. ALAN M. BATEMAN, of the Department of Economic Geology, Yale University, New Haven, Conn., has become editor of the *Journal of Economic Geology*.

MR. GEORGE G. BROWN, formerly chemical engineer with the Aluminum Co. of America, Messena, N. Y., and chemist for the development section, research division, Chemical Warfare Service, at the American University, Washington, D. C., is now chief engineer for the Universal Aniline Dyes & Chemical Co., Milwakee, Wis.

MR. E. C. CHERRINGTON and MR. T. R. COOLEY have been transferred from the Milwaukee office of the Cutler-Hammer Mfg. Co. to the Pittsburgh office in the capacity of office manager and engineering correspondent, respectively.

DR. FREDERIC DANNERTH has accepted an invitation from the Newark Technical School to deliver a course of thirty lectures on corporation chemistry.

MR. J. F. DEAN, formerly chemical engineer for the Southwestern Portland Cement Co., has resigned to become consulting chemical engineer for the Canada Cement Co. of Montreal. Mr. Dean has been especially active on matters connected with potash recovery.

LIEUTENANT-COMMANDER H. J. ELSON, U. S. Naval Reserve, has been released to inactive status and has resumed his position as secretary and treasurer of the Walter A. Zelnicker Supply Co., St. Louis, Mo.

CAPTAIN GEORGE H. HALL, Ordnance Department, Watertown Arsenal, has been discharged and resumed his position as manager of ozonator sales for the Sprague Electric Works of New York.

Mr. Arthur Lachman has resigned his position as vice-president and general manager of the Great Western Electro-Chemical Co. and the California Alkali Co. These connections were established in the interest of war production in needed chemicals but, that necessity no longer existing, Mr. Lachman will devote himself to his own interest with offices in the Holbrook Building, San Francisco.

Mr. John A. MacKenzie, consulting and designing engineer, formerly with E. B. Badger & Sons Co., is now connected with the Oakland Copper & Brass Works, Seventh and Kirkman Streets, Oakland, Calif.

Dr. Paul D. Merica, formerly of the metallurgical division of the Bureau of Standards, Washington, D. C., is now physical metallurgist in the research department of the International Nickel Co., Bayonne, N. J.

Mr. Philip N. Moore, past president of the American Institute of Mining and Metallurgical Engineers, has been appointed by the Secretary of the Interior to serve on the commission to adjust claims growing out of governmental efforts to stimulate production of war minerals. Mr. J. F. Shafroth and Mr. M. D. Foster are also on this committee.

Captain G. A. Roush has been discharged as chief of tests, metallurgical branch, inspection division, Ordnance Department, and has returned to his former position as assistant professor of metallurgy, Lehigh University, South Bethlehem, Pa.

Mr. F. V. Sargent has been appointed by the Chicago Pneumatic Tool Co. district manager of sales in the Boston territory, with headquarters at 182 High St., Boston, Mass.

Mr. A. J. Seltzer, former chemist for the Bartlesville Zinc Co., Blackwell, Okla., has opened an assay office in Picher, Oklahoma.

Mr. H. D. Trounce has accepted a position with the explosives division of the Bureau of Mines, with headquarters in Washington, D. C. His address will be Room 1128, the New Interior Building.

Mr. A. P. Watt was married on April 2 to Miss Ethel May Morse of Brooklyn, N. Y.

Obituary

Mr. H. R. Hancock, inventor of the jig and rock-drill that bear his name, died on Jan. 15 at the age of 83. Mr. Hancock was for twenty-two years in charge of the Wallaroo and Moonta copper mines in South Australia, which will now be managed by his eldest son, H. Lipson Hancock.

Mr. Alexander Cochrane, formerly president of the Cochrane Chemical Co. of Everett, Mass., died suddenly at his home at the age of 79. Mr. Cochrane was one of the original directors of the American Bell Telephone Co. and was identified with the development of its service.

Mr. Edward F. Freudenthal, mine operator and promoter of Pioche, Nev., died on March 24 at the age of 55 years. He was a native of Pioche and had always made his home there, although spending much time in Salt Lake City and in the East. He is survived by his widow, two sons and a brother.

Sir William Crookes, chemist and physicist, died in London April 4, 1919, at the age of 86. He was born in London June 17, 1832, and entered the Royal College of Chemistry at the age of 16. In 1851 he was assistant professor at the same institution. In 1859 he founded the *Chemical News* while in charge of chemical instruction at Science College, Chester. As editor of the *Chemical News* for sixty years Sir William enjoyed the distinction which has come to few if any editors of scientific papers. The discovery of thallium is credited to Sir William, resulting from an examination of the residue left in the manufacture of sulphuric acid. Crookes tubes and their familiar phenomena, known to every student of physics, were also his invention. Sir William was a publisher of many papers and books, among them being "Select Methods in Chemical Analysis," "Manufacture of Beet Root Sugar in England," "Handbook of Dyeing and Calico Printing" and translations of treatises on metallurgical and chemical technology. Sir William was knighted in 1904 and was the recipient of many honors from scientific societies in Europe. He was married in 1856 to Ellen, daughter of W. Humphrey. His wife died in 1916.

Mr. Harry E. Hollister died in Newark, N. J., on March 29. He was born in Newark on Nov. 29, 1887, and was graduated from the Newark Technical School in June, 1907. At the outbreak of the war he offered his services and was assigned to important duties in the development and construction of the large government powder plant at Nitro, W. Va. An article describing his work in this connection appears in this issue of this magazine. For several years he practiced his profession of chemical engineer, designing and building numerous chemical plants and developing several patented chemical apparatus and processes. Upon the cessation of hostilities he became associated with the Leonard Construction Co., New York, and was stricken while developing, on a commercial basis, one of his most valuable processes. At one time he was connected with Lockwood-Greene & Co., Boston, Mass., industrial engineers, and resigned to accept a position as assistant engineer with Harrison Bros. Co., Philadelphia, paint and chemical manufacturers, where he had charge of the design and construction of extensive chemical and paint manufacturing improvements. Later he was appointed chief engineer of the Kalbperry Corporation, New York, chemical engineers, and the Franklin H. Kalbfleisch Co., New York, chemical manufacturers.

Current Market Reports

The Non-Ferrous Metal Market

Saturday, April 12.—Prices on the non-ferrous metal market have not materially changed since our last report and demand has slackened to some extent.

Aluminium:—Conditions are unusually quiet, as aluminium has not declined. Ingots 98-99 per cent, 31c. lb. Sheets, 18 gage and heavier, 42c. Powder, 0.70-1.40 lb.

Antimony:—Wholesale lots are offered from 6¾ @ 7c. and jobbing at 7¼c. There was a slight improvement in buying.

Copper:—Moderate activity with slightly improved prices over our last report. The closing price was 15¼ @ 15⅝c. per lb.

Copper sheets, hot-rolled	lb.	$0.22½ — ....
Copper sheets, cold rolled	lb.	.23½ — ...
Copper bottoms	lb.	.30½ — ..
Copper rods	lb.	.19½ — ...
Copper wire	lb.	.17½ — $0.18
High brass wire and sheets	lb.	.18½ — .....
High brass rods	lb.	.17½ — .....
Low brass wire and sheets	lb.	.18½ — .....
Low brass rods	lb.	.21½ — ...
Brazed brass tubing	lb.	.29½ — ....
Brazed bronze tubing	lb.	.33½ — ....
Seamless copper tubing	lb.	.28 — ....
Seamless bronze tubing	lb.	.29½ — ....
Seamless brass tubing	lb.	.30 — ....
Bronze (gold) powder	lb.	1.00 — ....

Lead:—Prices have declined to 4.75c. per lb. in East St. Louis and 4.975c. per lb. in New York. Sheet lead, 7¾ @ 8c. per lb.

Tin:—The fixed price of 72½c. will remain until the 10,000-ton allotment is liquidated, which will be from sixty to ninety days yet.

Zinc:—Spelter has slightly improved in price and the East St. Louis price closed at $125 per ton. Zinc dust 14c.; sheet zinc, 11c. per lb.

OTHER METALS

Bismuth	lb.	$3.20 —$3.65
Cadmium	lb.	1.40 — ....
Cobalt	lb.	2.50 — 3.50
Magnesium	lb.	1.75 — 2.10
Mercury	75 lb.	67.00 — 70.00
Nickel	lb.	.40 — .45
Tungsten	lb.	Nominal
Iridium	oz.	175.00 — ....
Palladium	oz.	115.00 —120.00
Platinum	oz.	99.00 —100.00
Silver	oz.	1.01⅛ — ....

The Iron and Steel Market

The situation arising from the refusal of the Railroad Administration to place orders based upon the reduced prices recommended by the Industrial Board and effective

March 21 has been very generally misrepresented. It has been made to appear that the director general was refusing to do team work that he ought to do, for the general good, and his stand for the conservation of the public funds has not been placed to his credit. While the steel producers desire to obtain as high prices as possible for their products, some of them frankly commend the director general for his attitude, recognizing that he was endeavoring to do his duty.

As to the conflict between the statements of costs submitted by the steel producers to the Industrial Board and the attitude of the Railroad Administration that it can buy steel at lower prices if left to itself, this is all a question of overhead. There was a statement made, for instance, that the cost of producing bessemer rails in January was $46, but production was very light and necessarily a large overhead was charged.

There was undoubtedly a great difference of opinion between the steel producers and the Redfield board as to the demand that could be expected for steel. In vouchsafing but moderate reductions in steel prices, the reductions of March 21, together with those of last December, making an average of $11 a net ton from the Government schedule, not considering rails, the steel producers probably expected relatively light operations for several months. The Redfield board expected, undoubtedly, a fairly large demand for steel. If there were a large demand, the overhead would be so distributed that considerably lower prices could be accepted and still leave large profits, and the profits for 1919 will be taxed much less heavily than were those of 1918.

Sentimental Influences

It has been made to appear in many quarters that railroad buying would of itself produce much more activity in the steel trade. That is not true. The heaviest railroad buying that could possibly be expected, considering the uncertain position of the railroads, their light traffic and their earnings at very much below the Government guarantee, would amount to very little, in point of tonnage, to the steel trade. The hope was that if the Railroad Administration should buy with apparent freedom the public would then be moved also to buy, and its buying would furnish the really important tonnage. The public, however, had already given an inkling of its attitude as to the price reductions of March 21. Immediately after the reductions were announced there was a mild spurt in orders, but clearly this represented simply the orders that had been held back in anticipation. Now, when the total of bookings for the month of March can be scrutinized by the steel producers, they find that the spurt in buying did not make up for the previous lull, as compared with the buying rate in January.

It was expected that if the Railroad Administration endorsed the steel price reductions offered it would first buy rails, since rails are needed for upkeep. Cars and locomotives might follow, but it is not certain additional cars and locomotives will be needed in the near future. Improvements, by way of bridges, buildings, new lines, etc., would be farther in the future, and the undertaking of a comprehensive program would be of doubtful expediency when the disposition of the railroads has not been settled, or the conditions under which they will operate if, as seems altogether probable, they will be returned to their owners.

As to rail orders furnishing a stimulus to the steel industry, however, there were two unfortunate circumstances. Using open-hearth rails for illustration, bessemer rails being uniformly $2 less, the railroads had bought rails only at the $30 price which ruled up to May 1, 1916, then at $35, and then at the $40 price which became effective late in 1916. These were base prices, there being premiums for particularly stringent specifications. Last September the War Industries Board had approved a $57 price for open-hearth rails, which price obtained in various settlements for rails bought to prosecute the war, but the Railroad Administration never accepted the price. When, therefore, the Redfield board "reduced" rails from $57 to $47, it was asking the railroads to pay an advance. It is understood there is still due the railroads about 500,000 tons of rails at the basis price of $40 or less, on which shipments have been going out at the rate of 40,000 tons a week, which would carry the roads, in general, to July 1. It has not been shown that the railroads desire to lay rails at the rate of more than 40,000 tons a week. Thus in this matter of business being stimulated by the Railroad Administration buying rails there were two awkward circumstances—that what amounted to an advance in price was being asked, and that there was a fair supply of rails.

When the steel industry's capacity is fully 36,000,000 gross tons of finished steel products a year, the buying of a few hundred thousand tons more or less of rails cannot have much direct effect. The sentimental effect would be very considerable, perhaps, but that has not been proved. When the subject was so thoroughly aired it became certain that even should arrangements eventually be perfected whereby the Railroad Administration would buy, the sentimental effect would be lost. Accordingly sentiment has been growing in the steel trade that an open market is the only recourse, prices being allowed to go where they will. There is a disposition also toward a changed view in the matter of wages. With light operations the earnings of the men are very considerably reduced, and wage reductions might be effected without much complaint arising. Reasons that are largely sentimental in character are responsible both for the strenuous desire of Washington officials that wages be not reduced and for the equally strenuous desire of many steel producers that they be reduced. The latter would like to see reductions in order to preserve appearances, on account of repeated claims that steel prices could not be reduced unless wages were reduced.

The view that there should be an open market in steel is very far from universal, but it is growing more common. It is, perhaps, the optimistic view rather than the pessimistic. It looks to the possibility that an important volume of demand can thus be brought out. The other view is that demand cannot be materially stimulated and that prices should therefore be maintained, because of the high overhead per ton when operations are light.

Among the merchant furnaces the view has become quite general that there should be an open market, but pig iron is different from steel. The blast-furnaces have always had more or less competition between districts, and the recommended price schedule, which is simply $7.25 reduction from the Government schedule, with its complicated basings, entirely out of line with the alignments maintained by competition before Government price control began, must necessarily be unsatisfactory to one district if it proves satisfactory to another. The merchant furnaces feel that the way to reduce costs is to blow out, and many are doing so. Really competitive bidding cannot come, of course, until there is at least a moderate volume of inquiry, and thus far there has been practically none.

Production

Steel ingot production in 1918 is now reported by the American Iron and Steel Institute at about 43,027,000 gross tons, against 43,619,200 tons in 1917 and 41,401,917 tons in 1916. Since the middle of 1917 monthly reports of ingot production have been made by 29 companies. In 1916 these companies had made 88.14 per cent of the total output. In 1917 they made 85.1 per cent of the total, and completion of the 1918 total now shows that they made only 83.5 per cent of that year's output. This explains why the 1918 production proves to be slightly larger than had been indicated by previous estimates, based on the showing of the 29 companies. The estimates of rates of production in January and February of this year must also be revised. Reports are now made by 30 companies, which made 84.03 per cent of the 1918 total. On the basis of this 84.03 per cent, and counting the number of steel working days in the months and year, the country's rate of steel ingot production has been as follows: January, 42,600,000 tons, or 86.9 per cent of capacity, taken at 49,000,000 tons a year; February, 41,700,000 tons, or 85.1 per cent; March, 37,900,000 tons, or 77.3 per cent.

Even the March rate, although 11 per cent under the January rate, seems high in view of the generally reported stagnation in trade. The explanation offered by mills is that they are running chiefly on old orders, and they do not seem to expect new orders to take the place of old orders as they are worked out.

The Chemical Market

COAL-TAR PRODUCTS. — Producers generally report a marked increase in the volume of business for coal-tar products, although buyers are seemingly not disposed to bring their full demands in the market and seem to be confining their purchasing to immediate needs, but even this condition is having no effect in the steady increase in business. Consumers are becoming more reconciled to the market conditions, in view of the recent decline in prices, which appear to be more in accordance with their ideas. Producers are looking forward to an early resumption of activities and state they are well satisfied with the developments, apparently brought about, in part, by the settlement of the textile labor troubles, and this trade seems to be gradually becoming more active in purchasing dyes, which reflects materially on the crude and intermediate situation.

Phenol:—Considerable stock is reported to be changing hands, but second hands who were holding large quantities seem to be well sold up and the market has firmed up very noticeably.

Benzol: — Comparatively large quantities are reported being sold and second hands seem to have little if any material to offer, which tends to keep the market steady, and manufacturers are firmly maintaining prices.

Toluol: — Producers report a satisfactory business passing, but individual sales generally represent small lot transactions. Prices are quotably unchanged and the market is on a firmer basis.

Benzoate of Soda: — Resale offerings are still liberally made and in consequence lower prices have been brought about. The acid continues to be considerably neglected and keener competition among second hands has brought about some radical reductions in prices.

Alpha Naphthylamine:—Prices are firmly maintained by producers, despite the quietness generally prevailing.

Benzidine:—No important changes. The market is fairly active and steady at the recent decline in prices. There is a fair demand for the base product for export purposes, while local requirements are of moderate proportions and no particular interest is noted for the sulphate variety.

Beta Naphthol: — A fairly active trading is evident for the various grades, but available material is more than sufficient for the current call. However, no price changes have been effected, with a rather steady market prevailing.

Beta Naphthylamine:—Quotations for both the technical and refined products are held steady by producers, who report a fair volume of business passing, but the demand is by no means pressing.

Diethylaniline:—Large quantities are available at present, with new producers having recently entered the market. While the demand is slightly better, there are sufficient stocks for additional business and prices are lower.

Dimethylaniline:—There is not a great deal of business passing, despite the fact that offerings are made at some rather low levels and small lot trading continues to feature the market.

Naphthalene: — Buyers are displaying no unusual interest, but a fairly steady movement is reported at present, for the ball material, the activity being created by the drug trade, but trading even in this direction seems to be somewhat restricted. Some cheap offerings occasionally appear in the resale market, but trading for the most part is direct and manufacturers are making no price concessions to stimulate additional business.

Orthonitrophenol:—Trading is confined to small lots and stocks seem to have accumulated to a very noticeable extent, with offerings among second hands being made at 3c. to 5c. below manufacturers' prices.

Paranitrophenol:—While consumption requirements are of no unusual proportions, offerings are none too liberally made, but available supplies seem to be more than sufficient for the current call and the sales noted are closed at some low levels.

Paranitraniline: — Quantities of this material have now appeared on the market and keener competition among second hands has brought about some cheap offerings. Manufacturers are striving to keep the market steady and have not altered their prices since the recent decline.

HEAVY CHEMICALS.—Trading in the general market reflected a little more confidence in the ultimate betterment of conditions, although stocks in most instances are more than sufficient for the call. The bulk of the business is in limited quantities, but repeat orders are more frequent. Second hands are still, for the most part, the only factors actually doing anything in the way of active business, while manufacturers are seemingly not disposed to meet the resale market prices, but state a satisfactory business is developing and see no necessity for making any effort to meet this situation. Caustic soda and soda ash, the barometers of the heavy chemicals, seem to have been subject to a better call, particularly caustic soda, for which some important sales have been consummated for export purposes, and prices have been firmly maintained. On the other hand, no unusually large transactions were reported for soda ash, although trading has been of sufficient volume to take the slack off the market.

Soda Ash: — The consuming trade seems to be steadily taking a fair portion of supplies, but buyers are apparently not interested in any forward stocks and there seems to be sufficient spot material to meet the current call. Bag material from the warehouse was sold at $1.50 per 100 lb., with offerings made at this figure in some directions, but other quotations range up to $1.55 and $1.60. Double bags in the Middle West were nominally quoted at $2.15, while barrels ex store were as low as $1.60, with other directions holding at from $1.70 to $1.75.

Caustic Soda: — While the demand is not of a pressing nature there seems to be more interest on the part of buyers, and sales of 100 and 200 tons seem to have been more frequent at prices ranging from $2.75 to $2.80 f.a.s. per 100 lb. Second hands, who seem to control the market for the most part, were offering ex-warehouse material at from $2.65 to $2.70 and were offering on a basis of $2.75 to $2.80 f.a.s. Ground caustic continues to be neglected, with material available at 3½c. per pound.

Bleaching Powder: — There has been no increase in the interest for this commodity, particularly for local consumption, where buying seems to be conducted on a hand-to-mouth basis, while export trading seems to be somewhat more active. Large domestic drums were offered in the resale market at $1.60 ex-dock, and first hands are quoting this figure, at the works. Export drums were offered by second hands at 2¼c. f.a.s., with manufacturers holding at 2½c.

Bicarbonate of Soda:—The continued absence of any important demand has had its effect in the market and some resale lots were reported sold as low as $2.25. This, however, is not regarded as representative of the market, as material in barrels, in most directions, was held at $2.50 per 100 lb., while that in kegs was offered at from $2.65 to $2.70.

Bichromate of Soda:—Very little business. In fact, the market is so dull that reports are still heard of further reductions in prices. For instance, there were offerings of spot material as low as 10c. for some of the standard brands, while others were quoting 10¼c. to 10½c.

Caustic Potash: — Recent price reductions seem to have had some effect in stimulating business, although the present rate of absorbing stocks is having no effect, as the production of the material is reported to be quite heavy. Some grades of the 88-92 product are offered as low as 40c., with others still holding at 48c.

Cyanide of Soda: — There has been little in the way of active trading; however, the production of the commodity is confined to a few quarters, therefore prices are firmly maintained at from 30c. to 31c., according to quantity.

Copper Sulphate: — Little in the way of any important sales are noted and small lot transactions continue to feature the market. The production is probably heavier than for some time past and prices are easier at 7c. for outside brands, with other grades of the large crystals 99% being quoted at 7¼c.

Chlorate of Soda: — The continued absence of any important demand has had its effect of a weakening market, with price reductions noted in most directions. Sales were reported as low as 15c., although 17c. to 18c. seems to be the general market quotation.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET APRIL 8, 1919

Acetic anhydride	lb.	.65 —	.70
Actone	lb.	.15½ —	.16
Acid, acetic, 28 per cent	cwt.	3.25 —	3.40
Acetic, 56 per cent	cwt.	6.50 —	6.75
Acetic, glacial, 99½ per cent, carboys	cwt.	13.00 —	14.00
Boric, crystals	lb.	.13½ —	.15
Citric, crystals	lb.	1.20 —	1.22
Hydrochloric, (22%)	cwt.	2.50 —	3.00
Hydrofluoric, 30 per cent, in barrels	lb.	.08 —	.08½
Lactic, 44 per cent	lb.	.12½ —	.13
Lactic, 22 per cent	lb.	.05½ —	.06
Molybdic, C. P.	lb.	6.90 —	7.40
Nitric, 36 deg.	lb.	.06 —	.07
Nitric, 42 deg.	lb.	.07½ —	.08
Oxalic, crystals	lb.	.29 —	.30
Phosphoric, 47-50 per cent paste	lb.	.07½ —	.10
Phosphoric, ref. 50 per cent	lb.	.26 —	.30
Picric	lb.	.50 —	.60
Pyrogallic, resublimed	lb.	2.70 —	3.20
Sulphuric, 60 deg. works	ton	12.00 —	13.00
Sulphuric, 66 deg. works, tank cars	ton	17.00 —	20.00
Sulphuric, oleum (fuming), tank cars	ton	22.00 —	25.00
Tannic, U. S. P., bulk	lb.	1.40 —	1.50
Tartaric, crystals	lb.	.86½ —	.87
Tungstic, per lb. of WO_3	lb.	1.60 —	1.75
Alcohol, sugar cane, 188 proof	gal.	4.85 —	4.90
Alcohol, wood, 95 per cent	gal.	1.28 —	1.30
Alcohol, denatured, 180 proof	gal.	.40 —	.42
Alum, ammonia lump	lb.	.04½ —	.05½
Alum, chrome ammonium	lb.	.17½ —	.18
Alum, chrome potassium	lb.	.16½ —	.18½
Alum, chrome sodium	lb.	.12½ —	.13
Alum, potash lump	lb.	.10 —	.12
Aluminium sulphate, technical	lb.	.01½ —	.02½
Aluminium sulphate, iron free	lb.	.02½ —	.03½
Ammonia aqua, 26 deg., carboys	lb.	.07 —	.08½
Ammonia, anhydrous	lb.	.30 —	.35
Ammonium carbonate	lb.	.13 —	.14
Ammonium nitrate	lb.	.16 —	.17
Ammonium sulphate, domestic	lb.	.05 —	.05½
Amyl acetate	gal.	3.50 —	3.75
Arsenic, white	lb.	.09½ —	.10
Arsenic, red	lb.	.35 —	.40
Barium carbonate, 99 per cent	ton	80.00 —	90.00
Barium carbonate, 97-98 per cent	ton	65.00 —	67.00
Barium chloride	ton	70.00 —	80.00
Barium sulphate (blanc fixe, dry)	lb.	.03½ —	.04
Barium nitrate	lb.	.10 —	.11
Barium peroxide, basis 70 per cent	lb.	.30 —	.32
Bleaching powder, 35 per cent chlorine	100 lb.	1 60 —	2 25
Borax, crystals, sacks	lb.	.07½ —	.07¾
Brimstone, crude	ton	28.00 —	35.00
Bromine, technical	lb.	.55 —	.60
Calcium acetate, crude	lb.	.04 —	.05
Calcium carbide,	lb.	.05½ —	.06½
Calcium chloride, 75 per cent, fused, lump	ton	35.00 —	43.00
Calcium peroxide	lb.	1.50 —	1.70
Calcium phosphate	lb.	.22 —	.23
Calcium sulphate, 98-99 per cent	lb.	.09 —	.09½
Carbon bisulphide	lb.	.07 —	.08
Carbon tetrachloride, drums	lb.	.14 —	.15
Carbonyl chloride (phosgene)	lb.	.75 —	1.00
Caustic potash, 88-92 per cent	lb.	.40 —	.45
Caustic soda, 76 per cent	100 lb.	2.60 —	2.75
Chlorine, liquid	lb.	.08 —	.10
Cobalt oxide	lb.	1.60 —	1.65
Copperas	lb.	.01½ —	.02½
Copper carbonate	lb.	.31 —	.32
Copper cyanide	lb.	.65 —	.70
Copper sulphate, 99 per cent, large crystals	lb.	7.00 —	7.25
Cream of tartar, crystals	lb.	.56 —	.58
Epsom salt, bags, U. S. P.	100 lb.	2.25 —	2.35
Formaldehyde, 40 per cent	lb.	.22 —	.22½
Glauber's salt	lb.	.01½ —	.02
Glycerine, bulk, C.P.	lb.	.16½ —	.17
Iodine, resublimed	lb.	4.25 —	4.30
Iron oxide	lb.	.06 —	.08
Lead acetate, white crystal	lb.	.12½ —	.14
Lead arsenate (paste)	lb.	.15 —	.18
Lead nitrate, C. P.	lb.	.85 —	.86
Litharge, American	lb.	.09½ —	.10½
Lithium carbonate	lb.	1.50 —	...
Magnesium carbonate, technical	lb.	.15 —	.16
Nickel salt, single	lb.	.14 —	.15
Nickel salt, double	lb.	.12 —	.13
Phosgene (see carbonyl chloride)	lb.	.75 —	1.00
Phosphorus, red	lb.	.75 —	.80
Phosphorus, yellow	lb.	.35 —	.40
Potassium bichromate	lb.	.35 —	.36
Potassium bromide, granular	lb.	1.25 —	1.26
Potassium carbonate, calcined, 85-90 per cent	lb.	.17 —	.18
Potassium chlorate, crystals	lb.	.39 —	.41
Potassium cyanide, 98-99 per cent	lb.	Nominal	
Potassium iodide	lb.	3.75 —	3.80
Potassium muriate, 80-85 p. c. basis of 80 p. c.	ton	200.00 —	250.00
Potassium nitrate	lb.	.26 —	.30
Potassium permanganate, U. S. P.	lb.	.65 —	.75
Potassium prussiate, red	lb.	.85 —	.95
Potassium prussiate, yellow	lb.	.45 —	.55
Potassium sulphate, 90-95 p. c. basis 90 p. c.	ton	Nominal	
Rochelle salts	lb.	.46½ —	.48
Salammoniac, gray gran.	lb.	.14 —	.16
Salammoniac, white gran.	lb.	.12 —	.13
Salt soda	100 lb.	1.60 —	2.00
Salt cake	ton	12.00 —	14.00
Silver cyanide, based on market price of silver	oz.	...	...
Silver nitrate	oz.	.62½ —	.63½
Soda ash, 58 per cent, light, flat (bags)	100 lb.	1.50 —	1.55
Soda ash, 58 per cent, dense, flat	100 lb.	2.45 —	3.00
Sodium acetate	lb.	.07½ —	.08
Sodium bicarbonate, domestic	lb.	.02½ —	.02½
Sodium bicarbonate, English	lb.	...	...
Sodium bichromate	lb.	.12 —	.14
Sodium bisulphite, powd.	lb.	.05 —	.07
Sodium chlorate	lb.	.16 —	.18
Sodium cyanide	lb.	.30 —	.31
Sodium fluoride, commercial	lb.	.14 —	.15
Sodium hyposulphite	100 lb.	3.25 —	3.75
Sodium molybdate, per lb. of Mo	lb.	2.50 —	.....
Sodium nitrate, 95 per cent	100 lb.	4.07½ —	.....
Sodium nitrite	lb.	.13 —	.14
Sodium peroxide	lb.	.25 —	.30
Sodium phosphate	lb.	.03¾ —	.03¾
Sodium prussiate, yellow	lb.	.18 —	.22½
Sodium silicate, liquid (60 deg.)	lb.	.05 —	.05
Sodium sulphide, 30 per cent, crystals	lb.	.02 —	.02½
Sodium sulphide, 60 per cent, fused	lb.	.04 —	.05½
Sodium sulphite	lb.	.05½ —	.06½
Strontium nitrate	lb.	.25 —	.30
Sulphur chloride, drums	lb.	.07½ —	.09
Sulphur dioxide, liquid, in cylinders	lb.	.10 —	.12
Sulphur, flowers, sublimed	100 lb.	3.05 —	3.15
Sulphur, roll	100 lb.	2.70 —	3.10
Sulphur, crude	ton	35.00 —	37.50
Tin bichloride, 50 deg.	lb.	.27½ —	.28
Tin oxide	lb.	.65 —	.70
Zinc carbonate	lb.	.18 —	.20
Zinc chloride	lb.	.13½ —	.14
Zinc cyanide	lb.	Nominal	
Zinc dust, 350 mesh	lb.	.12 —	.13
Zinc oxide, American process, works	lb.	.09 —	.12
Zinc sulphate	lb.	.03¾ —	.04

Coal Tar Products (Crude)

NOTE—The following prices are for original packages in large quantities:

Anthracene, 80% in drums (100 lb.)	lb.	$0.90 —	$1.00
Benzol, pure, water-white, in drums (100 lb.)	gal.	.22 —	.27
Benzol, 90%, in drums (100 lb.)	gal.	.22 —	.27
Cresol, U. S. P., in drums (100 lb.)	lb.	.18 —	.....
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	1.02 —	.....
Cresylic acid, 95-97%, dark, in drums	gal.	.92 —	.....
Cresylic acid, 50%, first quality, drums	gal.	.60 —	.....
Dip oil, 25% tar acids, crudes, in drums	gal.	.38 —	.....
Phenol, U. S. P. drums (dest.), (240 lb.)	lb.	Nominal	
Pyridin	gal.	$2.50 —	.....
Naphthalene, crushed in bbls. (250 lb.)	lb.	.08½ —	.....
Solvent naphtha, water white, in drums, 100 gal.	gal.	.20 —	.25
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.18 —	.20
Toluol, in tank cars	gal.	.22 —	.....
Toluol, in drums	gal.	.23 —	.30
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	.....
Xylol, commercial, in drums, 100 gal	gal.	.32 —	.40
Xylol, commercial, in tank cars	gal.	.30 —	.....

Intermediates, Etc.

Alpha naphthol, crude	lb.	1.00 —	1.10
Alpha naphthol, refined	lb.	1.20 —	1.25
Alpha naphthylamine	lb.	.45 —	.50
Aniline oil, drums extra	lb.	.24 —	.25
Aniline salts	lb.	.32 —	.34
Anthracene, 80 per cent	lb.	.50 —	.55
Benzaldehyde (f.f.c.)	lb.	1.30 —	1.50
Benzidine, base	lb.	1.00 —	1.15
Benzidine, sulphate	lb.	.95 —	1.00
Benzoic acid, U. S. P.	lb.	1.15 —	1.20
Benzoate of soda, U. S. P.	lb.	1.10 —	...
Benzyl chloride	lb.	.50 —	...
Beta naphthol benzoate	lb.	5.50 —	6.00
Beta naphthol, sublimed	lb.	.65 —	.....
Beta naphthylamine, sublimed	lb.	2.50 —	2.55
Dichlorbenzol	lb.	.15 —	.20
Diethylaniline	lb.	2.25 —	2.75
Dinitrobenzol	lb.	.30 —	.35
Dinitrochlorbenzol	lb.	.30 —	.35
Dinitronaphtaline	lb.	.45 —	.55
Dinitrotoluol	lb.	.40 —	.50
Dinitrophenol	lb.	.32 —	.34
Dimethylaniline	lb.	.55 —	.60
Diphenylamine	lb.	.70 —	.75
H-acid	lb.	2.10 —	2.15
Metaphenylenediamine	lb.	1.55 —	1.75
Monochlorbenzol	lb.	.12 —	.14
Naphthalene, flake	lb.	.07 —	.08
Naphthalene, balls	lb.	.10½ —	.11½
Naphthionic acid, crude	lb.	1.20 —	1.30
Naphthylamin-di-sulphonic acid	lb.	1.00 —	1.10
Nitro naphthaline	lb.	.40 —	.45
Nitro toluol	lb.	.55 —	.60
Ortho-amidophenol	lb.	6.00 —	7.00
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-toluidine	lb.	.45 —	.50
Ortho-nitro-toluol	lb.	.45 —	.50
Para-amidophenol, base	lb.	3.25 —	3.65
Para-amidophenol, H. C. L.	lb.	3.25 —	3.75
Para-dichlor-benzol	lb.	.15 —	.20
Paranitraniline	lb.	1.15 —	1.25
Para-nitro-toluol	lb.	1.50 —	1.60
Paraphenylenediamine	lb.	3.15 —	3.25
Para toluidine	lb.	1.70 —	1.75
Phthalic acid anhydride	lb.	2.50 —	3.00
Phenol, U. S. P.	lb.	7.00 —	8.00
Resorcin, technical	lb.	4.50 —	5.00
Resorcin, pure	lb.	7.00 —	8.00
Salicylic acid, U. S. P.	lb.	.30 —	.35
Salol	lb.	.95 —	1.00
Sulphanilic acid, crude	lb.	.25 —	.31
Toluidine	lb.	2.15 —	2.25
Toluidine-mixture	lb.	.80 —	1.00

Waxes

Prices based on original packages in large quantities.

Bayberry	lb.	$0.40 —	$0.41
Beeswax, natural crude, yellow	lb.	.36 —	.39
Beeswax, refined, yellow	lb.	.40 —	.42
Beeswax, white, pure	lb.	.65 —	.68
Candelilla	lb.	.29 —	.30
Carnauba, flor	lb.	.82 —	.85
Carnauba, No. 1	lb.	.80 —	.81
Carnauba, No. 2, regular	lb.	.65 —	.70
Carnauba, No. 2, North Country	lb.	.55 —	.57
Carnauba, No. 3, North Country	lb.	.42 —	.44
Carnauba, No. 3, chalky	lb.	.42 —	.44
Cresin, yellow	lb.	.16 —	.17

Cresin, white	lb.	.16 —	.18
Japan	lb.	.12½ —	.14
Montan, crude	lb.	Nominal	
Montan, bleached	lb.	Nominal	
Ozokerite, crude	lb.	Nominal	
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.08 —	.08½
Paraffine waxes, crude scale, 117-119 m.p.	lb.	.08 —	.08½
Paraffine waxes, crude scale, 124-126 m.p.	lb.	.08 —	.08½
Paraffine waxes, refined, 118-120 m.p.	lb.	.10 —	.11
Paraffine waxes, refined, 123-125 m.p.	lb.	.10½ —	.11
Paraffine waxes, refined, 128-130 m.p.	lb.	.11 —	.11½
Paraffine waxes, refined, 130-132 m.p.	lb.	.11½ —	.12
Paraffine waxes, refined, 133-135 m.p.	lb.	.12 —	.13
Paraffine waxes, refined, 135-137 m.p.	lb.	.13 —	.14
Stearic acid, single pressed	lb.	.16 —	.17
Stearic acid, double pressed	lb.	.18 —	.....
Stearic acid, triple pressed	lb.	.19 —	.21
Spermaceti, block	lb.	.30 —	.31
Spermaceti, cake	lb.	.31 —	.32

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lbs.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$0.68
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.45
Pine tar oil, ref., sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.,	gal.	.33
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.58
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.38
Turpentine, crude, sp. gr., 0.900-0.970	gal.	.61
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.24
Hardwood oil, f.o.b. Mich., sp. gr., 1.06-1.08	gal.	.24
Pinewood creosote, ref.,	gal.	.48

Naval Stores

The following prices are F.o.b., New York, for carload lots.

Rosin B-D, bbl	280 lb.	$11.95 —	$12 20
Rosin E-I	280 lb.	11.95 —	12.35
Rosin K-N	280 lb.	13.00 —	14.00
Rosin W. G.-W. W	280 lb.	14.25 —	14.50
Wood rosin, bbl	280 lb.	12.25 —	.....
Spirits of Turpentine	gal.	.77½ —	.78
Wood Turpentine, steam dist	gal.	.72 —	.....
Wood Turpentine, dest. dist	gal.	.67½ —	.....
Pine tar pitch, bbls	200 lb.	8.00 —	8.25
Tar, kiln burned, bbl. (500 lbs.)	bbl.	12.50 —	13.50
Retort tar, bbl	280 lb.	13.50 —	14.50
Rosin oil, first run	gal.	.68 —	.78
Rosin oil, second run	gal.	.70 —	.80
Rosin oil, third run	gal.	.82 —	83
Rosin oil, fourth run	gal.	.85 —	95

Vegetable Oils

Unless otherwise noted, the following prices are f.o.b., New York.

Castor oil, No. 3, in bbls	lb.	$0.21 —	$0.23
Castor oil, AA, in bbls	lb.	.24 —	.25
China wood oil, in bbls	lb.	.18½ —	.20
Cocoanut oil, Ceylon grade, in bbls	lb.	.14 —	.15
Cocoanut oil, Cochin grade, in bbls	lb.	.15 —	.17
Corn oil, crude, in bbls	lb.	.16½ —	.17½
Cottonseed oil, crude (f.o.b. mill)	lb.	.17½ —	.....
Cottonseed oil, summer yellow	gal.	.22 —	.....
Cottonseed oil, winter yellow	gal.	.23½ —	.24
Linseed oil, raw, car lots	gal.	1.50 —	1.52
Linseed oil, raw, tank cars	gal.	1.45 —	1.48
Linseed oil, boiled, car lots	gal.	1.53 —	1.55
Olive oil, commercial	gal.	2.25 —	2.50
Palm, Lagos	lb.	.20 —	.....
Palm, bright red	lb.	.18 —	.19
Palm, Niger	lb.	.15 —	.16
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.16 —	.18½
Peanut oil, refined, in bbls	lb.	.19½ —	.21
Rapeseed oil, refined, in bbls	gal.	1.50 —	1.65
Rapeseed oil, blown, in bbls	gal.	1.55 —	1.65
Soya bean oil (Manchurian), in bbls., N. Y	lb.	.14½ —	.15
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.12½ —	12¾

Miscellaneous Materials

All Prices F.o.b., N. Y.

Barytes, domestic, white, floated	ton	$30.00 —	$36.00
Barytes, off color	ton	22 00 —	27.00
Blanc fixe, dry	lb.	.03½ —	.04½
Blanc fixe, pulp	ton	30.00 —	45.00
Casein	lb.	.17 —	19
Chalk, English, extra light	lb.	.05 —	.07
Chalk, English, light	lb.	.04½ —	.06
Chalk, English, dense	lb.	.04 —	.05
China clay (Kaolin), imported, lump	ton	35.00 —	.....
China clay (Kaolin), imported, powdered	ton	60.00 —	.....
China clay (Kaolio), domestic, lump	ton	15 00 —	20.00
China clay (Kaolin), domestic, powdered	ton	35.00 —	40.00
Feldspar	ton	11.00 —	15.00
Fluorspar, acid grade, lump, f.o.b. mines	net ton	3 .00 —	37.00
Fluorspar, acid grade, ground, f.o.b. mines	net ton	40.00 —	45.00
Fuller's earth, domestic, powdered	ton	30.00 —	40.00
Fuller's earth, imported, powdered	ton	... —	....
Graphite, domestic	lb.	.08 —	.14
Graphite, Ceylon	lb.	08 —	.18
Graphite, Madagascar	lb.	.10 —	.15
Graphite, Mexican	lb.	.01½ —	.03½
Pumice stone, imported	lb.	03 —	06
Pumice stone, domestic	lb.	None	
Shellac, TN	lb.	.46 —	.47
Shellac, D.C	lb.	.75 —	....
Shellac, V. S. O	lb.	.72 —	.75
Shellac, Diamond I	lb.	.72 —	....
Shellac, orange, fine	lb.	.52 —	.56
Shellac, orange, superfine	lb.	.54 —	.55
Shellac, A.C. garnet	lb.	.46 —	.50
Shellac, bleached, bone dry	lb.	.50 —	.56
Shellac, bleached, fresh ground	lb.	.46 —	....
Soapstone	ton	15.00 —	25 00
Talc, domestic	ton	20.00 —	60 00
Talc, imported	ton	Nominal	

Refractories

Following prices are f. o. b. works:

Chrome brick	net ton	$120.00 at Chester, Penn.
Chrome cement	net ton	65.00 at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	40–30 at Clearfield, Penn.
Clay brick, 2nd quality	net ton	38–48 at Clearfield, Penn.
Magnesite, dead burned	net ton	32.50–35.50 at Chewalah, Penn.
Magnesite brick, 9 x 4½ x 2½ in	net ton	80–90 at Chester, Penn.
Silica brick	net ton	45–55 at Mt. Union, Penn.

Ferro-alloys

Resales and overstocks make above prices approximate.

All prices f. o. b. works.

Ferro-titanium, carbon free	lb.	$0.40 —	.....
Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y	net ton	$200.00 —	$300.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.32 —	.40
Ferro-chrome, per lb. of Cr. contained, 2 % carbon	lb.	.70 —	.....
Ferro-manganese, 70-80% Mn	gross ton	130.00 —	150.00
Spiegeleisen, 16-20% Mn	gross ton	40.00 —	50.00
Ferro-molybdenum, per lb. of Mo	lb.	3.00 —	3.50
Ferro-silicon, 50%	gross ton	90.00 —	115.00
Ferro-silicon, 75%	gross ton	150.00 —	175 00
Ferro-silicon, 10-15%	gross ton	50.00 —	60.00
Ferro-tungsten, 70-80%, per lb. of contained W	lb.	1.30 —	1.50
Ferro-uranium, 35-50%, of U	lb.	7.00 —	.....
Ferro-vanadium, 30-40%, per lb. of contained V	lb.	5.50 —	7 00

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	Nominal	
Chrome ore, 48% and over	unit	$1.00 —	$1.25
Coke, foundry, f.o.b. mines	net ton	4.50 —	.....
Coke, furnace, f.o.b. mines	net ton	3.75 —	.....
Petroleum coke, f.o.b. Atlantic seaboard	net ton	16.00 —	16.50
Fluorspar, gravel, f.o.b. mines	net ton	18.50 —	20.00
Manganese ore, 45% Mn and over	unit	.85 —	.....
Manganese ore, chemical (MnO_2)	gross ton	60.00 —	70.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75 —	.85
Tungsten, Scheelite, 60% WO_3 and over per unit of WO_3	unit	9.00 —	10.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	7.00 —	10.00
Uranium oxide, 96%	lb.	..... —	.....
Vanadium pentoxide, 99%	lb.	6.00 —	.....
Pyrites, foreign, lump	unit	.17 —	.....
Pyrites, foreign, fine	unit	.17 —	.....
Pyrites, domestic, fine	unit	.14 —	.....
Ilmenite, 50% TiO_2	net ton	30.00 —	.....
Rutile, 95% TiO_2	net ton	160.00 —	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	3.00 —	3.25

Resales and overstocks make above prices approximate.

Plant Materials and Supplies

In carload lots, New York, unless otherwise stated.

BUILDING MATERIALS

Portland cement, at dock, without bags		bbl.	$2.30
Lump lime, common, including container	300	bbl.	2.65
Common brick, at dock		M	15.00
Hollow building tile,	8x12x12	M	194.40
" At factory, Perth Amboy, N. J.,	12x12x12	M.	291.60
Yellow pine, 3x4 to 8x8, 20-24 ft. long		M.	39.00
Yellow pine, 3x4 to 8x8, 20- 4 ft. long at Chicago		M.	38.50
Yellow pine, 3x4 to 8x8, 20- 4 ft. long at St. Louis		M.	35.00
Roofings, tar felt (14 lb. per 100 sq.ft.)		ton	52.00
Roofings, tar pitch (in 400-lb. bbl.)		ton	19.00
Roofings, asphalt pitch		ton	36.00
Roofings, asphalt felt		ton	67.50
Roofings, slate-surfaced shingles, per roll of 108 sq.ft			2.10
Roofings, slate-finished shingles, 100 sq.ft			5.50
Linseed oil, raw in barrels		gal	$1.58
Linseed oil, 5 gal. cans		gal.	1 73
Red lead, dry, 100 lb. keg		lb.	13
Red lead, in oil, 100 lb. keg		lb.	14¼
Red lead, dry, 5 lb. cans		lb	15
Red lead, in oil, 5 lb. cans		lb.	16½
White lead, dry and in oil, 100 lb. keg		lb.	13
White lead, dry and in oil, 25 and 50 lb. kegs		lb.	13¼
White lead, dry and in oil, 5-lb. cans		lb.	15

STRUCTURAL STEEL, MILL, PITTSBURGH

Beams and channels, 3 to 15-in.	100 lb.	$2 45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.66
Plates	100 lb	4 20
Rivets, structural, ½-in. and larger	100 lb.	4.30
Rivets, conehead for boilers, ½-in. and larger	100 lb.	4 35
Sheets, No. 28 black	100 lb.	3.55
Sheets, No. 10 blue annealed	100 lb.	4.05
Sheets, No. 28 galvanized	100 lb.	5.70

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

POWER HOUSE SUPPLIES

In standard quantities

Hose, Fire Underwriters' 2½-in., in 50-ft. lengths	ft.	$0.75
Hose, air, ¾-in., first grade	ft.	.55
Packing, rubber and duck for low pressure	lb.	.90
Packing, asbestos for high pressure	lb.	1.60
Packing, duck and rubber for piston	lb.	1.00
Babbitt metal, best grade	lb.	87
Babbitt metal, commercial	lb.	42
Wiring supplies, New York:		
Friction tape, ¾-in., 100 lb. lots	lb.	.48
Rubber tape, ¾-in., 100 lb. lots	lb.	.60
Wire solder, 100 lb. lots	lb.	.46
Soldering paste, 2 oz. cans Nokorode	doz	1 20

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Arizona

BISBEE—The Phelps-Dodge Corp. plans to resume work on concentrator.

CLIFTON—The city voted $150,000 bonds for the construction of sanitary sewers and treating plant. A. J. Kerr, town engineer.

GLOBE—The Iron Cap Mines Co. is having plans prepared by D. Cole for a mill.

JEROME—The United Verde Extension Mining Co., 233 Broadway, New York City, N. Y., plans to build extensions and additions to its copper smelter, here. G. Kingdon, general manager.

PRESCOTT — The Arizona Binghamton Mining Co. is having plans prepared by D. Cole for the construction of a mill and tramway. Estimated cost, several hundred thousand dollars.

Arkansas

ASHDOWN—The United Oil Mills plans to build a 2-story, 130 x 160-ft. oil mill and will require equipment for same. W. Foster, president.

LITTLE ROCK—The Dixie Cotton Oil Co., east of North Little Rock, will install a 12-press mill, in connection with the 2-story, 60 x 240-ft. oil mill which it plans to build. Total estimated cost, $250,000. W. F. Birdville, general manager.

California

LOS ANGELES—The Hollywood Studios, Inc., 6980 Hollywood Blvd., has awarded the contract for the construction of a motion picture plant, on Santa Monica Blvd., to the Milwaukee Building Co., Wright & Callender Bldg.; plans include the installation of film developing rooms. Total estimated cost, $250,000.

Connecticut

HARTFORD—The Board of Water Commissioners has awarded the contract for building a slow sand filtration plant, to the Foundation Co., 233 Broadway, New York City. Estimated cost, $627,508.

HARTFORD — The Hartford Rubber Works, 691 Park Ave., plans to build a 1-story, 60 x 80-ft. addition to its rubber factory on Booth Ave. Estimated cost, $18,000.

Idaho

QUARTZBURG—The Gold Hill & Iowa Mines Co. plans to build a mine plant, to include a mill, concentrators, cyanide plant, etc, and is in the market for cyanide machinery. Estimated cost, $300,000. E. E. Carter, superintendent.

Illinois

CHICAGO—E. H. Frommann, architect, 64 West Randolph St., is receiving bids for the construction of a 2-story, 125 x 200-ft. factory on Cortland and Kilbourne Sts., for the National Enameling & Stamping Co., 346 West Kinzie St. Estimated cost, $85,000.

ROCK ISLAND — C. W. Scott, 1338 2nd Ave., Davenport, Ia., has awarded the contract for the construction of a 1-story, 40 x 150-ft. factory for galvanizing to K. H. Cox, 905 Kirkwood Blvd., Davenport, Ia. Estimated cost, $3500.

Kansas

TREECE—The Big Elk Mining Co. plans to move Dorris mill from Quapaw and erect same at Treece, and is in the market for gas engine, rolls, rock drills and tables. C. Kelly, superintendent.

WESTVILLE—The Lucky Jew Mining Co., Commerce, Okla., plans to build a concentrating plant here. E. Depree, superintendent.

Kentucky

LOUISVILLE—The C. C. Stoll Oil Co., Shelby and River Sts., plans to build a refinery.

Louisiana

NEW ORLEANS — The New Orleans Petroleum Co., Woolworth Bldg., New York City, will build an oil refinery 15 miles from here. Estimated cost, $1,500,000. Work will be done by day labor.

Maryland

BALTIMORE — The Baltimore Copper Smelting & Rolling Co., 4th and 5th Aves., plans to build an addition to its plant.

HANCOCK—The Maryland Glass Sand Co., Hagerstown, plans to build a mill near here. Estimated cost, $50,000. R. J. Funkhouser, president.

Massachusetts

ASHLAND—The United States Color & Chemical Co., 15 Custom House, Boston, has awarded the contract for the construction of a 2-story, 50 x 84-ft. research building here, to the Pennsylvania Tile & Construction Co., 45 Milk St., Boston. Estimated cost, $50,000. Noted Feb. 15.

Michigan

DETROIT — The Central Forge Co., Euclid Ave., has awarded the contract for the construction of a 2-story, 70 x 302-ft. heat-treating plant and a 2-story, 70 x 302-ft. forge shop, on Euclid Ave. and Grand Trunk Railway tracks, to the Whitehead & Kales Iron Works, Beecher Ave. and Michigan Central R. R.

Missouri

ST. JOSEPH—The Conser Laundry Co., 908 Francis St., is in the market for one water softening plant, oil burners and a 12,000-gal. oil tank, etc. H. S. Lewis, chief engineer.

ST. LOUIS — The Mineral Refining & Chemical Co., Iron Mountain tracks and Des Pere River, plans to build an addition to its paint and pigment plant. Mineral milling equipment will be installed in same. Total estimated cost, $500,000. A. E. F. Versen, c/o owner, engineer.

ST. LOUIS—G. W. Niedringhause, 3745 Lindell St., vice president of the National Enameling Stamping Co.; C. Studebaker of the Studebaker Corp., 4300 Forest Park Bldg., and others plan to build a coke pig iron plant at Granite City. Estimated cost, $7,000,000.

ST. LOUIS—The Yawitz Dyeing & Cleaning Co., Suburban and Whittier Sts., will install a chemical laboratory in the 1- and 2-story, 50 x 135-ft. dyeing and cleaning factory, which it plans to build on Delmar and Walton Sts. Estimated cost, $50,000. S. Yawitz, president.

WACO—The Freehold Oil & Gas Co. plans to build a mill at its No. 3 shaft. W. S. Marquiss, manager.

WACO—C. Windbigler, Joplin, plans to move Old Jasper County mill from Prosperity and erect same at Waco, and is in the market for pumps, rock drills, belting and hoist. Estimated cost, $50,000. C. Windbigler, manager.

WEBB CITY—The Carlat Mining Co. plans to remodel and enlarge its plant, and is in the market for boilers, gas engine, rolls and belting. C. Cornett, manager.

Montana

BUTTE—The Boston & Montana Development Co., Daly Bank Bldg., plans to build a concentrator, and is in the market for complete concentrating equipment, coarse and fine crushing tables, etc. Estimated cost, $150,000. J. D. Pope, superintendent.

New Jersey

MILLVILLE—The Eastern Potash Co., 120 Broadway, New York City, plans to build a factory on the banks of the Raritan River here. Estimated cost, $2,000,000.

NEWARK—The General Leather Co., 420 Frelinghuysen Ave., has awarded the contract for the construction of a 2-story, 38 x 64 ft. drying building, to E. M. Waldron, Inc., 665 Broad St. Estimated cost, $14,000.

NEWARK—Nickelsburg Bros. Co., Meadow St. and Lincoln Highway, is having plans prepared by O'Rourke & Briscoe, architects, 45 Clinton St., for the construction of a 3-story, 50 x 100-ft. plant. Estimated cost, $30,000. Miller & Moran Chemical Works, lessees.

NEWARK—The Radel Leather Manufacturing Co., Wilson Ave., has awarded the contract for the construction of a 1-story, 40 x 110-ft. factory on Wilson Ave. and Central R. R. tracks, to the Reynolds Construction Co., 308 South 9th St. Estimated cost, $5000.

NEWARK—The Weldon Roberts Rubber Co., 117 Mechanics St., has awarded the contract for altering the 3-story, 86 x 112-ft. factory at 18 Oliver St., to Oschwald & Schmidt, 845 Broad St. Estimated cost, $10,000.

PHILLIPSBURG—The City Commissioners have approved $150,000 bond issue for the construction of a new sewer and sewage oxidation plant. C. E. Tilton, city engineer.

PHILLIPSBURG—The City Commissioners voted $65,000 bond issue for the construction of a sewage disposal plant and sewer lines. C. E. Tilton, city engineer.

New York

BROOKLYN—The Brooklyn Maternity Hospital, 670 Bushwick Ave., will install a chemical laboratory in the 4-story, 75 x 100-ft. hospital which it plans to build on Bushwick Ave. and Adams St. Total estimated cost, $70,000. M. Duckman, treasurer. Carlson & Wiseman, 226 Henry St., architect.

BUFFALO—The Mentholatum Co., 146 Seneca St., will soon award the contract for the construction of a 5-story, 100 x 160-ft. factory on the corner of Niagara and Brace Sts. Estimated cost, from $150,000 to $200,000.

COBLESKILL—D. D. Frisbie, president of the Board of Trustees, Schoharie State School of Agriculture, at the office of the Commissioners of Agriculture, State and Lodge Sts., will soon award the contract for the construction of a 2-story, 40 x 70-ft. school; plans include the installation of two laboratories. Estimated cost, $50,000.

CORTLAND—J. B. Webster, 3 Main St., and others have purchased the Redway Garage on Groton Ave., and will install an acetylene plant, metal working machinery, drill press, planer, miller, etc.

FREDONIA—The Bone Dry Lime Co. plans to build a plant for the manufacture of agricultural lime from the Cassadaga Lake marl, near here. Lime burning equipment, rock crushers, etc., will be installed in same. C. E. Smith, Franklin, president.

GOUVERNEUR—The Nestles Food Co. plans to remodel and reconstruct the plant which it purchased from the International Milk Products Co. last season. Additional equipment will be installed in same. Estimated cost, $100,000.

JAMESVILLE—The Farmers' Consumers Carbide Co., recently incorporated by F. M. Hennessey, 3rd National Bank Building, Syracuse, and others with $125,000 capital, plans to establish furnaces and calcium plant here. Estimated cost, $25,000.

LONG ISLAND CITY—The Famous Players-Lasky Corp., 485 5th Ave., New York City, has awarded the contract for the construction of a 3-story, 90 x 120-ft. laboratory and a 4-story, 100 x 200-ft. studio on Pierce, Graham, 5th and 7th Aves., to the Fleischmann Construction Co., 531 7th Ave., New York City. Estimated cost, $2,000,000.

LONG ISLAND CITY—The General Carbonic Co., 444 Van Brunt St., Brooklyn, has awarded the contract for the construction of a 1-story factory on 6th St. and West Ave., to the Austin Co., 217 Broadway, New York City. Plans include the installation of a chemical laboratory. Estimated cost, $200,000.

NEWARK—The city voted $280,000 bonds to build a gravity water supply system. Work includes pipe line involving 1750 tons of cast-iron pipe, 1,000,000 gallon rapid sand filtration plant, earth dam and dike, etc. J. P. Wells, Cutler Building, Rochester, consulting engineer.

NIAGARA FALLS—The Defiance Paper Co., Walnut and 3rd Sts., plans to build an addition to its pulp mill. Pulp grinders, rotary screens, etc., will be installed in same. Estimated cost, $18,000.

Ohio

CLEVELAND—The Harshaw, Fuller, Goodwin Co., Electric Bldg., has awarded the contract for the construction of a 1-story, 30 x 50-ft. addition to its varnish factory at 1002 Howard St., to the Hunkin-Conkey Co., 601 Century Bldg. Estimated cost, $15,000.

CLEVELAND—The Reflex Ignition Co., Superior Bldg., has awarded the contract for

the construction of a 2-story, 80 x 160-ft. factory on West 110th St. and N. Y. C. Railway, to S. W. Emerson Co., 1900 Euclid Bldg. Estimated cost, $65,000.

COLUMBUS—The Atlantic Refining Co., Hartman Bldg., plans to build a refinery.

COLUMBUS—The Columbus Pharmacal Co., 332 Oak St., plans to build a 3-story, 43 x 84-ft. factory. Estimated cost, $55,000. O. Darst, Brunson Bldg., archt.

MAUMEE—The State Board of Health has ordered the city to have plans prepared for a sewage disposal plant or trunk sewer to connect with Lucas Co. sewerage system to eliminate discharge of sewer into Maumee River. G. Champe, 610 Nasby Bldg., Toledo, engineer.

Oklahoma

CLAREMORE—The city plans election soon to vote on $82,000 bonds for sewer improvements, to include the construction of a sewage disposal plant, sanitary sewer extensions, etc.

EUFAULA—The city plans election soon to vote on $40,000 bonds to extend and improve the waterworks system, to include the installation of a Pittsburgh filtering plant at the pumping station as well as a 12-in. intake pipe.

Oregon

ASTORIA—The Astoria Pulp & Paper Co. has awarded the contract for the construction of a 40 x 250-ft. addition to its pulp and paper mill on 11th St. and Taylor Rd., to P. Trullinger. Estimated cost, $25,000. Noted Mar. 1.

CORVALLIS—The State Legislature has appropriated $60,000 for the construction of a 2-story, 56 x 220-ft. engineering laboratory at the Oregon Agricultural College here. J. V. Bennes, architect, Chamber of Commerce Bldg., Portland, preparing plans.

Pennsylvania

BETHLEHEM—The Traveler Tire & Rubber Co., 819 North Broad St., Philadelphia, plans to build a 2-story, 60 x 250-ft. rubber mill here. Estimated cost, $250,000. J. O. Hunt, 114 North Montgomery St., Trenton, N. J., architect.

CLARENDON—The Union Petroleum Co., Widener Bldg., Philadelphia, plans to rebuild the portion of its refining plant here recently destroyed by fire.

MONESSEN—The city plans to build an incinerating plant. A. J. Knight, president of the City Council.

Texas

FT. WORTH—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of an argon production plant here, to the Dawson Construction Co., 810 Union Trust Bldg. Estimated cost, $431,000. (180 days.)

FT. WORTH—The Creosoting Lumber Corp. plans to build a creosoting plant here, to have an initial capacity of 5000 barrels. Estimated cost, $75,000. E. Morrel, secretary.

STEPHENVILLE—The Duke Consolidated Oil Co. plans to build an oil refinery.

Virginia

NORFOLK—The Bureau of Yards & Docks, Navy Department, Washington, D. C., will receive bids until April 21 for the construction of a galvanizing and oxy-acetylene plant here. Estimated cost, $108,000. Specification No. 2772.

West Virgina

MARTINSBURG—X. Poole and others plans to build dehydrating plant for apple products and is in the market for machinery for same.

Wisconsin

SHEBOYGAN—R. L. Frome, Howards Grove, has awarded the contract for the construction of a 2-story, 35 x 80-ft. glue factory on Calumet Drive, to R. Eisman. Estimated cost, $6500.

British Columbia

SLOCAN—M. S. Davys plans to improve existing plant and install a new concentrator. Estimated cost, $120,000.

Ontario

GUELPH—The Partridge Rubber Co., Ltd., Metcalfe St., plans to build a 3-story, 60 x 100-ft. factory. Estimated cost, $60,000. James, Loudon & Hertzberg, Excelsior Life Bldg., Toronto, engineers.

OTTAWA—The Ottawa Gas Co., Sparks St., plans to build a water-gas plant on Lees Ave., East Ottawa. Estimated cost, $850,000. A. A. Dion, 35 Sparks St., superintendent.

OWEN SOUND—W. Kennedy & Sons, 1114 1st Ave., West, plans to build an addition to its steel plant, to include the installation of equipment for two cupolas for smelting iron and elevators. Estimated cost, $85,000.

TIMMONS—The Hollinger Mines plans development, to include the construction of a plant and the installation of machinery. Estimated cost, $500,000. E. F. Brigham, engineer.

Quebec

TEMISKAMING—The Kipawa Co. plans to build pulp and paper mills. Estimated cost, $5,000,000. G. T. Lamb, Montreal, engineer.

Cuba

HAVANA—The Cuban Air Reduction Co., 120 Broadway, New York City, plans to build a 2-story, 98 x 108 ft. acetylene plant here. Estimated cost, $100,000.

Coming Meetings and Events

THE AMERICAN ASSOCIATION OF ENGINEERS will hold a meeting at 29 S. LaSalle St., Chicago, May 13 and 14.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its 22nd annual meeting at Atlantic City, N. J., June 24-27. The headquarters will be at the Hotel Traymore.

THE AMERICAN ZINC INSTITUTE will hold its annual meeting at St. Louis, Mo., June 9-10, instead of May 12, as announced in our April 1 issue.

THE NATIONAL FOREIGN TRADE COUNCIL will hold its sixth national foreign trade council at the Congress Hotel, Chicago, Ill., on Thursday, Friday and Saturday, April 24, 25 and 26, 1919.

THE NATIONAL SERVICE COMMITTEE of the Engineering Council will hold a meeting at Chicago, Ill., April 23 to 25.

Industrial Notes

Organization of Electric Furnace Association

At a meeting held at Niagara Falls on March 21 and 22 an organization was perfected to promote the use of electric-furnace products. The organization is known as the Electric Furnace Association and comprises manufacturers of electric furnaces, electrical apparatus, electric-furnace supplies and accessories, designers and inventors of electric-furnace equipment and the users of electric furnaces. The purpose of the organization is to lay before the consumers of electric-furnace products the advantages of those materials. Special emphasis was laid on electric steel, the tonnage of which showed remarkable increase throughout the world during the last four years.

The meeting was attended by representatives of the General Electric Co., Westinghouse Electric and Manufacturing Co., American Metallurgical Corp., Industrial Electric Furnace Co., T. W. Price Engineering Co., Booth-Hall Co., Hamilton & Hansell, Ludlum Electric Furnace Co., Pittsburgh Electric Furnace Co., Fitz-Gerald Laboratories, Carborundum Co., Norton Co. and Acheson Graphite Co.

A permanent organization was created with the following officers: President, Acheson Smith, Acheson Graphite Co., Niagara Falls; first vice-president, C. H. Booth, Booth-Hall Co., Chicago; second vice-president, W. E. Moore, Pittsburgh Electric Furnace Co., Pittsburgh; secretary, C. G. Schluederberg, Westinghouse Electric & Manufacturing Co., Pittsburgh; treasurer, F. J. Ryan, American Metallurgical Corp., Philadelphia; directors, the officers and C. A. Winder, General Electric Co., Schenectady, and F. J. Tone, Carborundum Co., Niagara Falls.

Committees were created as follows: Publicity: C. H. Booth, chairman, C. A. Winder, C. G. Schluederberg and A. B. Oatman. Data: W. E. Moore, chairman, J. A. Seede, A. M. Williamson, F. J. Ryan, F. A. J. FitzGerald and C. A. Vom Baur. Fields: F. T. Snyder, chairman, F. J. Tone, H. A. DeFries and S. L. Walworth.

The second meeting was held in New York April 3, at which the tentative draft of the constitution and by-laws was adopted. An aggressive campaign for members was planned to include all manufacturers of electric furnaces, electric-furnace supplies, electric steel, electric brass, electric power and designers and inventors of furnaces.

THE STURTEVANT MILL CO., Boston, Mass., announces the establishment of new offices, at Room 619 Singer Bldg., 149 Broadway, N. Y. C. These offices are in charge of the company's former Western sales manager, Mr. J. S. Vrabek, recently promoted to the position of Eastern sales manager.

THE NEWARK TECHNICAL SCHOOL, Newark, N. J., announces a special course in corporate chemistry by Dr. Frederic Dannerth. The aim will be to show the application and the principles of industrial chemistry to manfacturing problems. It will cover:

1. Sources of raw materials.
2. Executive departments, purchasing, manufacturing and selling.
3. Advisory departments, engineering, law and research.
4. Laboratory management.
5. Economic office organization management.

Further details can be obtained from Mr. D. R. Hodgdon, director.

A. P. GREEN FIRE BRICK CO., Mexico, Mo., has opened an Eastern district sales office at 30 Church St., New York City. Mr. Howard C. Thayer, formerly field mechanical engineer for the J. G. White Corp. at the U. S. Nitrate Plant No. 2, is in charge.

THE STEPHENS-ADAMSON MFG. CO. of Aurora, Ill., has recently established a new sales office in Cincinnati, Ohio, to give attention to this particular territory. Mr. John G. Stewart, who has been associated with the Stephens-Adamson Manufacturing Co. for fifteen years, had been appointed district manager.

CHARLES F. AMES CO., 90 West St., New York City, has been appointed to act as the New York sales department of the Platt Iron Works, Dayton, Ohio.

THE PHOENIX IRON WORKS CO., Meadville, Pa., has opened a New York office, Room 619, Fifth Ave. Bldg., in charge of Mr. J. E. Kindregan and Mr. Paul C. Rodgers. Mr. Kindregan continues representing this company as district sales manager, with an office in the Harrison Bldg., Philadelphia, Pa., and will devote only a part of his time in the company's interest at New York. In addition to the New York territory, Mr. Rodgers will also continue the representation of the company at Boston.

MR. HERMAN A. HOLZ has moved his office and laboratories to the Pullman Bldg., 17 Madison Ave., New York City. The laboratories will contain equipment for experimental heat-treating, hardness and impact testing, micro- and macro-photographic investigation of metal sections, apparatus for magnetic measurements and for investigating the mechanical properties of steel products by determination of their correlated magnetic characteristics, also equipment for X-ray work on metal products.

THE ISLAND REFINING CO., a subsidiary of the Island Oil & Transportation Co., has been formed to refine the oil of the latter company, which has a potential production of 35,000,000 bbl. of oil per year. Col. G. A. Burrell of Pittsburgh, Pa., has been elected president of the new company.

THE U. S. COPPER PRODUCTS CO., Cleveland, Ohio, has placed an order with the General Electric Co., Schenectady, N. Y., for a brass-melting furnace of the muffled arc type having a capacity of 2200 lb. per hour.

THE ASPROMET CO. of Pittsburgh, Pa., announces that the name of the company has been changed to the H. H. Robertson Co.

OSAKA BOEKI KAISHA, LTD., Osaka, Japan, solicits correspondence with American dealers in chemicals and metals with the object of securing Japanese and Korean representation of American lines.

JOSEPH BOUKEZ & CIE, Alexandria, Egypt (address P. O. Box 604), general importers specializing in chemicals, iron and steel, cement and building materials, desire representation of American lines.

THE W. A. JONES FOUNDRY & MACHINE CO., of Chicago, Ill., manufacturers of power transmission apparatus, special foundry and machine work and also the Jones spur gear speed reducer, have opened an Eastern office at 30 Church St., New York, under the direction of Mr. Lemuel C. Biglow, who formerly for a number of years held a similar position with the Morse Chain Co., of Ithaca, New York.

THE METAL & THERMIT CO., New York City, is issuing a large map calendar showing the new railroad time zones in the United States which went into effect Jan. 1, 1919.

THE AIR REDUCTION SALES CO., New York, at the organization meeting of directors held Feb. 19, 1919, elected the following officers: Mr. A. S. Blagden, president; Mr. A. R. Ludlow, vice-president; Mr. C. E. Adams, treasurer; Mr. M. W. Randall, secretary; Mr. C. L. Snow, assistant treasurer; Mr. C. C. Emerson, assistant secretary.

THE NATIONAL ANILINE & CHEMICAL CO., New York, held its annual meeting of stockholders and a subsequent meeting of directors on Feb. 17 and 19 respectively. Officers and directors were elected as follows: President and chairman of the board, William J. Matheson; vice-presidents, Dr. William Beckers, Robert Alfred Shaw and Dr. L. C. Jones; acting treasurer, William H. West; assistant treasurers, H. S. Trott and T. S. Baines; secretary, William T. Miller; assistant secretary, Walter E. Rowley; chairman of executive committee, Henry Wigglesworth. The personnel of the board is as follows: Dr. William Beckers, New York; H. H. S. Handy, Syracuse; Dr. L. C. Jones, Syracuse; Clinton S. Lutkins, New York; William J. Matheson, New York; Eugene Meyer, Jr., New York; W. N. McIlravy, New York; F. M. Peters, New York; T. M. Rianhard, New York; Robert Alfred Shaw, New York; I. Frank Stone, New York; Dr. P. C. Taggesell, Buffalo; Orlando F. Weber, New York; Henry Wigglesworth, New York.

DR. EMIL E. LUNGWITZ, chemical and industrial engineer, 90 West St., New York City, has opened an office at 14 East Jackson Blvd., Chicago, Ill., under the management of Mr. H. L. Dick.

THE EPPING-CARPENTER PUMP CO., Pittsburgh, Penn., announces the appointment of Mr. P. S. Healey as manager of sales in addition to his former office of chief engineer. Mr. F. F. Woods is now located in New York as Eastern sales manager. Mr. Albert A. Scheuch of the sales department has been appointed as assistant sales manager, and Mr. Paul D. Goodman, formerly of the McClary Jemison Machinery Co. of Birmingham, Ala., has been added to the sales personnel.

THE BROWN-STEEL CO., Columbus, Ohio, has been incorporated to take over the steel department of the Columbus Mill & Mine Supply Co. of that city.

THE BECKWITH MACHINERY CO., Arch St. and Parkway, Northside, Pittsburgh, has opened an office and warehouse at 1227 West 9th St., Cleveland, for the sale of the regular lines of mine, mill and construction equipment marketed by this company.

BARZILLAI G. WORTH, vice-president of Walter Kidde & Co., Inc., has been elected treasurer of the Monmouth Chemical Co., also having charge of manufacturing and research. This company produces potassium chlorate electrolytically, using processes and apparatus developed by Walter Kidde & Co., Inc., under Mr. Worth's direction. During the war and at the instance of the United States Government Mr. Edward Schwarz, chemical engineer of the Kidde organization, succeeded in developing for the Monmouth Chemical Co. a new bromate-free chlorate product surpassing the German standard. This was done in co-operation with the work of the Ordnance Department to eliminate the causes for ammunition failures reported to Congress in the early stages of the war by Secretary Baker.

THE HYDRO ELECTRIC POWER COMMISSION, Ontario, Can., placed an order with the Westinghouse Co., for two 45,000 k.v.a. vertical water-wheel generators of 12,000 volts, 3-phase, 25-cycles, for their Queenstown development. These will be the largest water-wheel generators ever constructed.

THE ATMOSPHERIC CONDITIONING CORP. of Philadelphia, Penn., is the new name of the organization which, after Apr. 1, will manufacture and market the air conditioning apparatus and the Webster system of humidifying control formerly handled by the Braemer Air Conditioning Corp. The equipment includes Webster air washers, humidifiers, dehumidifiers, generator coolers, etc. The officers of the new corporation are: Mr. John F. Hale, president; Mr. William J. Strandwitz, vice-president; Mr. Herbert A. Terrell, secretary and treasurer; Mr. E. Nesdahl, chief engineer. Mr. Warren Webster, president and general manager of Warren Webster & Co., is a member of the board of directors. Territorial officers are already established in many of the larger cities of the United States and Canada and also in London, England.

New Publications

Tycos Tables is a publication recently gotten out by the TAYLOR INSTRUMENT COMPANIES, Rochester, N. Y. This new edition gives general data concerning and for use with temperature indicating, recording and controlling instruments; hydrometers and meteorological instruments. Price, $1.00.

NEW BUREAU OF STANDARDS PUBLICATIONS: Scientific Paper No. 332. Preliminary determination of the thermal expansion of molybdenum. By Lloyd W. Schad and Peter Hidnert; Circular No. 78. Solders for aluminium; Technologic paper No. 118, A critical study of the Ledebur method for determining oxygen in iron and steel. By J. R. Cain and Earl Pettijohn.

NEW BUREAU OF MINES PUBLICATIONS: Tech. Paper 196. Notes on the black sand deposits of Southern Oregon and Northern California. By R. R. Hornor; Bull. 172. Abstracts of current decision on mines and mining. By J. W. Thompson; War Minerals Investigations Series No. 9, Problems involved in the concentration and utilization of domestic low-grade manganese ore. By Edmund Newton.

THE MINES EXPERIMENT STATION AND ITS RELATION TO THE IRON MINING INDUSTRY OF MINNESOTA. Published by the School of Mines, University of Minnesota, Minneapolis, Minn., Feb., 1919.

MANGANESE AND CHROMIUM IN CALIFORNIA. By Walter W. Bradley, Emile Huguenin, C. A. Logan, W. Burling Tucker and Clarence A. Waring. Bulletin 76, dated August, 1918, published by the California State Mining Bureau, San Francisco, Calif.

QUICKSILVER RESOURCES OF CALIFORNIA. By Walter W. Bradley of the California State Mining Bureau. This is Bulletin No. 78, and is the first work published in 15 years dealing distinctly with quicksilver and its metallurgy. It includes an account of the original investigations on concentration of quicksilver. Copies may be obtained for $1.50 postpaid, from the State Mining Bureau, Ferry Bldg., San Francisco, Calif.

THE FEDERAL BOARD FOR VOCATIONAL EDUCATION is issuing a series of "Opportunity Monographs," dealing with various forms of employment for disabled soldiers and sailors. The purpose of the series is to give these men the information that will assist them in choosing a vocation. Monographs have been published on the following subjects: Series No. 6, Safety and Fire Protection Engineering; Series No. 9, Oxy-Acetylene Welding; Series No. 13, Concrete Construction and Cement Manufacture; Series No. 14, Electrical Employments with Utility Companies; Series No. 15, Electrical Construction, Maintenance, and Repair Occupations; Series No. 16, The Law as a Vocation.

CANADIAN DEPARTMENT OF MINES PUBLICATION: Preliminary Report of the Mineral Production of Canada During the Calendar Year 1918. Prepared by John McLeish, published Feb. 27, 1919.

Manufacturers' Catalogs

THE ESTERLINE CO., Indianapolis, Ind., publishes each month the "Esterline Graphic." The pamphlet on hand deals with power factor surveys, which is of special interest to central stations and industrial plants. This company will be glad to send to anyone interested information on graphic recording instruments of the portable, wall or switchboard type.

THE W. S. ROCKWELL CO., 50 Church St., New York, is distributing Bull. 41 to interested parties, upon application. This bulletin covers the subject of heating furnaces for billets, wire bars and cakes. The text and illustrations aim to give a comprehensive account of the heating operations involved, including suggestions as to the types of furnaces found best suited to various plant and manufacturing requirements.

THE WHEELER CONDENSER & ENGINEERING CO., Carteret, N. J., has published preliminary Bull. 113, illustrating and describing a steam jet air pump containing two or more steam jets working in series with a condenser between the jets. The bulletin gives engineering data on the operation of the pump.

THE SEMET-SOLVAY CO., Syracuse, N. Y., calls attention to a new catalog on Solvay protective paints. This 32-page booklet deals with crysollite protective, graphite, stack, acid-resisting and hydraulic paints, concrete coatings and general directions about the use of these materials. Price list No. 53 is supplemented with the booklet.

THE CUTLER-HAMMER MFG. CO., Milwaukee, Wis.: "C-H Molded Insulation" is the title of a new 2-color, 16-page booklet which describes thermoplax and pyroplax, the trade names of the heat-resisting and fire-resisting Insulations made by this company which can be molded into countless sizes and shapes for all purposes.

THE AMERICAN-LA FRANCE FIRE ENGINE CO., INC., Elmira, N. Y., has issued a Safety-First catalog, Edition D, which deals not only with the first aid to the injured, but also with resuscitation, safety signs, respirators, masks, pure air helmets and hoods, and many other appliances for the protection of workers, giving illustrations as well as descriptive matter. The "ambrine" surgical dressing is noted, first-aid equipment and cabinets are illustrated and described, also an improved stretcher and other equipment such as rubber gloves, leggings, protective suits, safety oil cans, portable lamps, etc., which devices all make for the preservation of life, health and property.

Stocks and Bonds

Closing Bid and Asked Quotations April 11, on N. Y. Stock Exchange

CHEMICAL COMPANIES

	Bid	Ask		Bid	Ask
Am.Ag.Ch....	108⅛	108½	Mat.Al.Wk..	31	36
do.pf.....	100	100½	Ten. C. & C..	13⅜	14
Barrett Co...	131	132	Un. Dyewood.	58½	61
do.pf.....	114½	115	do. pf.....	95	96
Gen.Chem....	173	179	Va.-Car. Ch.	60½	60⅝
do.pf.....	102½	104	do. pf.. ..	112	113
Int.Ag.Ch....	20½	21			
do. pf.....	72½	74			

Bonds

Am. Ag. Ch., 1st cv. 5s, '28.....	99	99½
Am. Ag. Ch., cv. db. 5s, '24.....	105	110
Int. Ag. Ch., 1 mtg. & col. tr. 5s, '32...	81½	81½
Va.-Car. Ch., 1 mtg. 5s, '23	95½	96
Va.-Car. Ch., cv. db. 6s, '24	101½	102

PETROLEUM COMPANIES

	Bid	Ask		Bid	Ask
Asso. Oil Co..	75	79½	P-A Pet & Tr.	82	82½
Cal. Pet.....	25½	26	do. pf.....	143	148
do. pf.....	69½	70½	Pierce Oil....	20	20½
Col. G. & E..	45½	45½	Royal Dutch..	97	92½
Mex. Pet.....	181½	182½	Sinclair O & R	49½	49½
do. pf.....	103½	106	Texas Co.....	213½	214
Ohio Cit. Gas.	41½	41½	Tex. Pac. Ld.		
do. pf.....			Tr.....	200	230
Ohio Fuel S...	45	46	Tidewater Oil.	210	215
Okla. P. & R..	10½	10⅝			

Bonds

Columbia Gas & Electric, 1 5s, '27.....	87	89
Col. G. & El., std. 1 5s, '27	83	89
Pan-Am. Pet. & Tr. 1 6s, '19-'27.....	130	
Pierce Oil, cv. db. 6s, '24.....	97½	98
Pierce Oil, cv. 5% Notes, '20.....	107½	108
Sin. O. & R. 1 In.7s, '20, with stk. war...	106	
Sin. O. & R. 1 In. 7s, '20 without stk. war..	97	97½
Texas Co., db. 6s, '31	10?	103
Union Oil of Cal. 1 5s, '31.	93	94
United Fuel Gas 1 mtg. 6s, ser.A, '36....	95½	96

IRON AND STEEL SECURITIES

	Bid	Ask		Bid	Ask
Am. St. F....	81½	82	Pitts.Ste. pf..	93	94
Beth. Steel...	73	76	Rep. Iron &		
do. class B.	75½	76	Steel.....	87⅜	83
do. pf., 8%.	107	107½	do. pf.....	102½	10..⅜
do. pf., 7%.	95	96	Sloss Sheff. I.		
Central Fdry.	13	21	& S.....	52	55
do. pf.....	30½	34	do. pf.....	84	88
Col. F. & I...	42½	42	Superior Steel.	40	40½
do. pf.....	105	125	do. 1 pf..	97½	98½
Cruc. Steel...	67⅛	67½	Trans. & W.		
do. pf.....	93⅜	94½	Steel.....	44½	45
Great No. Ore	41½	41½	Un. Alloy St..	4..⅛	43
Gulf Sta. Steel	53	55	U.S.C.I.P.&F.	22⅜	73½
do. 1 pf.. .	92½	98½	do. pf.....	59	60
Lack. Steel...	70½	70½	U. S. Steel....	98½	98½
Mid.St.& Ord.	47½	47½	do. pf.....	116½	116½
Nova Scotia			Va. Coal, I&C.	54	57
Steel.....	47	....			

Bonds

Beth. Steel, 1 ext. gtd. S.F. 5s, '26.....	95½	96
Beth. Steel, 1 In. ref. 5s, Ser. A, '42	88	99
Beth. Steel, P. M. & I. S. F. 5s, '36.....	84	85
Buff. & Susq. Iron, 1 S. F. 5s, '32.....	91	96
Buff. & Susq. Iron, deb. 5s, '27		
Cent. Found. 1 mtg. S. F. 6s, '21.....	78	87
Col. F. & I., gn. S. F. 5s, '43.....	89	90
Ill. Steel, db. 4½s, '40	83½	84
Ind. Steel, 1 mtg. gtd. 5s, '52.....	95½	96
Lack. Steel, 1 5s, '23.....	96⅜	96½
Lack. Ste., 1 con. mtg. cv. 5s, Ser. A, '50	88¼	90½
Mid. St. & Ord., clt. cv. S. F. 5s, '36	88½	88¾
Nat. Tube, 1 mtg. gtd. 5s, '52	95½	96
Rep. I. & S., S. F. mtg. 5s, '40.....	97⅜	94
Tenn. C. & I. R.R., gn. 5s, '51	91	97
U. S. Steel, S. F. 5s, '63.....	100¼	100⅜
Va. C., I. & C., 1 5s, '49.....	85½	85⅞

Published SEMI-MONTHLY *on the* FIRST *and* FIFTEENTH *of each month*

CHEMICAL & METALLURGICAL ENGINEERING

A *consolidation of* ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

McGRAW-HILL COMPANY, INC.
Tenth Avenue at 36th Street
NEW YORK

JAMES H. McGRAW, President
ARTHUR J. BALDWIN, Vice President E. J. MEHREN, Vice President
J. MALCOLM MUIR, Vice President EDWARD CALDWELL, Treasurer
JAMES H. McGRAW, JR., Secretary

TELEPHONE, 2840 Greeley CABLE ADDRESS, Machinist, New York

WASHINGTON, Colorado Bldg. SALT LAKE CITY, Newhouse Bldg.
CHICAGO, Old Colony Bldg. PHILADELPHIA, Real Estate Trust Bldg.
SAN FRANCISCO, Rialto Bldg. CLEVELAND, Leader-News Bldg.
LONDON, 6 Bouverie St., E. C. 4. BUENOS AIRES, Calle Corrientes, 685.

H. C. PARMELEE, Editor
ELLWOOD HENDRICK, Consulting Editor
ERNEST E. THUM, Western Editor
WALLACE SAVAGE, Assistant Editor

Yearly Subscription price for United States, Mexico and United States dependencies, $3; all other countries, $4. Single Copy, 25c.
When change of address is ordered, the NEW and the OLD addresses must be given. Notice must be received at least 10 days before change takes place. No back copies for more than three months.

Copyright, McGraw-Hill Co., Inc., 1919. Entered as second-class matter July 13, 1918, at the Post Office at New York, N. Y., under the Act of Congress of March 3, 1879.

Circulation of this issue 12,900 *copies*

CONTENTS *for May* 1, 1919

Volume, XX, *Number* 9

EDITORIAL

National Integrity, Personal Responsibility and the Victory Loan 449
Has Heat Treatment Been Demonstrated? 449
Bolsheviks and Research 450
The Way to Prosperity 450
Alignment of the Steel Industry 451

READERS' VIEWS AND COMMENTS

Rapid Electrolytic Copper Assay Without Rotating Cathode. By *Richard G. Place* 452
The Perchloric Acid Method for Potash in Cement Materials. By *William F. Newberry* 452
Credit to Whom Credit Is Due. By *Fred Petzold* 453
Flakes in Steel. By *Haakon Styri* 453
Standard Form for Mexican Claims 453
Bids Requested on Chlorine 453
Western Chemical and Metallurgical Field 454
Symposium on Pyrometry at Fall Meeting of the A. I. M. E. 455
Use for Surplus TNT 455
Imports of Tungsten-Bearing Ore 455
Import License Proposed 456
Merck Stock to be Auctioned 456
New Jersey Chemical Society Spring Meeting 456
American Bureau of Welding 456
"Hamlet" With Hamlet Left Out 457
Metallic Coatings for Rust-Proofing Iron and Steel—I. By *Henry S. Rawdon, M. A. Grossman* and *A. N. Finn* 458
Potash From Wood Ashes 464
War Department Disposes of Lead 464
Treatment of Cuprodescloizite for Extraction and Recovery of Vanadium, Lead and Copper. By *J. E. Conley* 465
The Edgewood Arsenal 469
The Oxidation of Ammonia. By *W. S. Landis* 470
Lead Poisoning 477
Flaky Fractures and Their Possible Elimination. By *Haakon Styri* 478
Request for Quotation on Borax 483
Metal Strapping on Wooden Boxes 483
Recovery of Waste Paraffined Paper 483
Bituminous Roofing Materials and Construction—II. By *George Landis Wilson* 484
Recent Chemical and Metallurgical Patents 487
Vom Baur Electric Furnace. By *C. H. Vom Baur* 488
Personal 489
Current Market Reports 489
Imports and Exports 492
Industrial, Including Construction and Operation, Coming Meetings and Events, Industrial News, New Publications and Stocks and Bonds 495

National Integrity, Personal Responsibility and the Victory Loan

OUR soldiers are coming home. On April 25 over 23,000 arrived in New York harbor, and each day sees thousands more returning to resume their places as civilian workers. Hundreds of thousands still remain in Europe to finish the job they started; and seventy thousand, more or less, who represent the price in human life which the United States paid for world peace, sleep under the little white crosses that mark our soldiers' graves in France. Upon us devolves the welcome duty of paying the money debt incurred by the vast preparations necessary to support those thousands who are now returning, and those other thousands who made the supreme sacrifice.

Speaking of sacrifice, how little the average American citizen knows about it in connection with the war. None went hungry or naked; all slept peacefully, secure from invasion, pillage or death; few gave up luxuries and fewer still denied themselves necessities; except for a few gasless Sundays, our automobiles worked about as usual; Liberty bonds were bought out of our abundance, and created a bigger capitalist class than the country ever knew before. We knew not the terror of the air raid or the long-range bombardment, nor did we see the flower of our youth fall by the million in battle until our whole nation was in mourning. It is scarcely becoming to speak of sacrifice on the part of the majority of our people.

The work is yet to be finished, and the Victory loan is made for that purpose. As portrayed in the colored supplement to this issue of CHEMICAL & METALLURGICAL ENGINEERING, Liberty makes this final appeal in the name of those whose graves dot the soil of France.

Has Heat Treatment Been Demonstrated?

ONE is accustomed, when thinking of things connected with the manufacture of modern machine parts, to assume that heat treatment actually has been demonstrated. That is to say, that factory or shop executives universally recognize the fact that the physical properties of metallifactures may be altered and adjusted by a properly selected schedule of heating and cooling.

But evidently not so! A case in point occurred in the year of grace 1918, in a shop belonging to a huge Western railroad system. The mechanical engineering authorities were evidently wide awake; they knew the elastic limit and ductility required for various engine repair-parts, and these properties were specified and obtained. The forge shop was well in line, too; for instance, when making locomotive driving rods, special attention was given to produce a finished piece which would forthwith pass the rather exacting physical re-

quirements, and in order to reduce the discouragingly large number of rejections, the foreman had installed a pyrometer in his heating furnace, which was carefully kept at a certain reading.

Still rejections were even at best all too common—perhaps two for every good rod produced. Of course these beautiful heavy forgings were not altogether lost, for some economical body decided to cut them up for smaller pieces of less importance whereby many dollars were saved to help Uncle Sam win the war!

One day a metallurgist from a steel company was at these shops endeavoring to adjust a purchasing-department claim. He noticed a big side-rod in process of demolition and on inquiry discovered the conditions just outlined. Being naturally curious, he inquired why an effort was not made to adjust the physical properties of the completed forging by an anneal, and was startled by the information from the shop superintendent, "One of our men thinks that some of them might be passed in that way, but heat treatment is still in the experimental stage and we are in no position to monkey with it. All our energies are required for production." This certainly was a poser, but the inquisitive visitor was militant as well, and on a long-odds wager, placed three excellent but rejected rods in an end-fired tunnel furnace —the only thing immediately available—turned on the flame, heated them until one portion began to color, then let them soak for a time, and repeated the process until the bars had gradually passed the transformation range —judging temperatures entirely by eye. After cooling from this crude operation, fresh tests from the forgings passed the ductility limit easily.

The foreman paid the wager with a smile, as well he might, since the gain was a hundred dollars for each one lost, yet he retains the original practice! What will get beneath the skin of "rule-of-thumb," "practical" methods, anyway?

Bolsheviks and Research

PROBABLY few would dispute the assertion that there is no industrial research now under way in bolshevik Russia. True, the civilized world lacks definite knowledge as to this and other particular points, but by inference the statement is approximately correct. If a governing body decides that executives of industrial enterprises are excrescences on the body politic to be forthwith lopped off, surely the workman-managers do not need a bespectacled scientific staff to tell them how to improve process, performance or production.

Americans, especially Americans who are managers or directors, think of bolshevism and soviets as a child thinks of bogey-men, and any one of them would hotly resent any insinuation that his mental processes were bolshevikian—devil take it and all its works! But in more than one recent instance, such a manager or such a director has started to "reduce the cost" of his product by eliminating that most essential part of his technical organization, the research staff. A bolshevist would have pushed his mistaken idea to the limit, though. He would have fired the manager, the auditor, and even the director himself. The insinuation is, therefore, immediately withdrawn.

Doubtless it is only reasonable to presume that research organizations instituted during the affluence of war-times should be regarded as non-essentials, and their appropriations refused before their work was well under way, when the product is not selling with its former ease and volume. Such a research was instituted, not because the management realized the need for it, but because it was stylish, or because the concern had more money than it cared to turn over to Uncle Sam. Luxuries and side issues can now be dispensed with, it is true; but it is truer that properly organized research is neither a luxury nor a side issue.

It is almost an axiom derived from experience that the surest way to increase the use of an article is to cheapen its cost so that it can be marketed at a lower price. Now in the ultimate analysis, the cost of any article, no matter how simple or how intricate, depends upon the money spent for labor and the money absorbed by capital, taxes or royalties—in brief, for "labor" and for "capital." At times even the directors have aimed to reduce costs, always by the doubtful expedient of cutting labor rates, seldom touching capital costs except as a last resort. The technical management, on the other hand, often has the best will in the world to reduce labor costs by increasing the efficiency of the men and machines, but, pray, who is to point the way in which more production can be had from a dollar's worth of raw materials or an hour's human labor, if it is not the research department?

This argument is almost self-evident to the technical man. It may happily reach and convince the executive. His conversion would doubtless be easier if he could realize that by increasing labor and technical efficiency is found the only way in which present capital charges can be maintained. But human nature is the same everywhere—even in high places they buy dear on a rising market, and scramble to sell when things are cheap!

The Way to Prosperity

LET us try to clear the industrial atmosphere with a few plain truths. First: We are not going to return to pre-war conditions, economically, socially, industrially or commercially—nor do we want to. Second: Economic law is as basic and sound as scientific law or engineering fact, and disaster is quite as certain to overtake those who violate the one as those who ignore the other. Third: The people now need education in economics even more than prior to the war, so that certain fundamental facts will be widely understood and appreciated. Fourth: Failure to realize and accept the changes, and ignorance of their cause, is largely responsible for the lull in business activity—the valley of depression in the curve of industry and commerce; conversely, a knowledge of fundamentals would remove hesitancy, uncertainty and gloom, and enable business to step forward with confidence and cheerfulness.

Fortunately for all of us the voices of the economist and sociologist are being heard in the land, but they need reinforcement and transmission to a larger audience. It seems scarcely necessary to attempt to prove that pre-war conditions generally have gone for good. The war itself was a social revolution, a protest against autocracy in politics. Is there anything startling in the corollary that autocracy likewise must be removed from industry? This explains the social unrest, the aspirations of the worker, the necessity for recognizing a new order in human relations. Likewise the war caused an inflation of currency and credit that is responsible for the high prices of commodities, and the establishment of a permanent new high-price level in

business. Prices are not going back to pre-war levels, as a general proposition, and wages must remain high in order to meet the increased cost of living. There will be changes until the most glaring discrepancies are removed, but in general prices and wages are up to stay. If the changes are proportionate, we are all just as well off as before. The great necessity is to realize the futility of talking about lower prices and wages or waiting for them to come.

In an analysis of the causes for present prices, MR. O. P. AUSTIN, statistician for the National City Bank, New York City, finds that the first contributing cause was a "scarcity demand" for war materials. This cause, however, would not explain the concurrent rise in prices of commodities that found no place in war and for which no war demand existed. Looking deeper into the matter, he finds that world inflation of currency is the fundamental cause, paper money with a face value of $36,000,000,000 having been issued by the countries at war, excluding the currency issued by the bolsheviki. Practically all of this is an acceptable medium of exchange in the country of its origin. Add to this the $180,000,000,000 of bonds that the responsible nations of the world have issued, and which are in effect a basis for obtaining money; and the $50,000,000,000 increase in world bank deposits, and we are not surprised when MR. AUSTIN pertinently observes:

"If the world's historians and financiers and economists and statisticians are right in their general belief that any advance in prices usually accompanies or closely follows inflation in currency, and especially in paper currency, can we be surprised at the world-wide advance in prices which we have witnessed during the past four years in which world currency and bank deposits trebled and national debts quintupled?"

Deflation is not in sight, and that is the only hope for materially lower prices. Isn't it about time to rely upon the laws of economics and go ahead with business? The question answers itself. Intelligent conclusions drawn from the facts point irresistibly toward resumption of business, realizing that the change that has taken place is one of degree only, and that the great need of the hour is a combination of optimism and wisdom that will bring about resumption by resuming.

Alignment of the Steel Industry

THE steel industry has been the "prince or pauper" industry so long and it has so generally been regarded "the barometer of trade" that we have insensibly fallen into the habit of regarding it as a foregone conclusion that if business is good the steel industry will thrive, while if business is not good the steel industry will languish. That is, the steel industry has nothing to do with its own destiny. It is assumed to come about naturally that the industry is too small when times are good and too big when times are bad. After all, however, it would be decidedly curious if such a doctrine should work out right all the time.

On the one hand, the war caused the American steel industry to expand greatly, productive capacity having increased by fully 40 per cent since 1914. On the other hand, the war stopped nearly all construction work, and it is in construction work that steel finds its chief demand. It is true that tin cans are used but once, that wire fence rusts away and that some steel is used in making tools, automobiles and various things that have but a limited life. The heaviest employment of steel is in construction works, which are established as investments, in bridges, factories, hotel and office skyscrapers, power plants, transmission lines, oil and gas pipe-lines and similar enterprises. What is the balance between the increase in steel-making capacity and the halt in construction work, both caused by the war?

Existing capacity should be compared with production or consumption before the war rather than with capacity at that time. In the five years, 1905 to 1909 inclusive, the production of steel ingots in the United States averaged 20,325,000 tons a year. In the next five years, through 1914, the average was 26,313,000 tons. Capacity at present is about 50,000,000 tons.

Plainly this is a very large increase to be taken care of. It is true that pig iron production has very nearly doubled every ten years, while the production of steel has increased somewhat more rapidly; but if it were possible to divide all steel consumption, year by year, into transitory and permanent use, into classes represented respectively by tin cans and beams, it would probably be found that the latter class has increased more rapidly than the former. No point is strained, by the way, in using the tin can as an illustration, for the production of tin plate in the past two years has been at a greater rate, in point of tonnage, than the production of all structural shapes in any year prior to 1905.

The demand for steel for construction purposes rests upon no whim, but upon a collection of very definite factors. In essense, the steel is bought by an investor, who does some careful figuring. He estimates what the property will return in annual earnings, and makes allowance for amortization. He considers the cost of the steel, the cost of the other materials that must be used at the same time, and the cost of the labor necessary to convert the steel and other materials into the final work. Then he checks up the whole matter by estimating how much the same thing would cost one year or two years hence. If a saving in first cost is shown, that has its own value, and there is coupled with it the fact that one year or two years hence the investor will have clearer vision as to the future earning power of the investment.

As to steel demand in the remainder of the world, the comparison between the American and foreign industries is favorable in one respect and unfavorable in another. Taking the American steel industry as representing 50,000,000 tons of ingots a year, the British industry is between 20 and 25 per cent as large; the French industry, cut in half by the war, and to be reconstituted but slowly, represents not much over 5 per cent; the German industry represents between 15 and 20 per cent, and the Belgian industry is practically destroyed. The total is hardly more than 40 per cent, apart from capacity in Canada, Japan, India, Italy, etc. If the world wants much steel it must come to the United States, and in that respect the alignment is very favorable. On the other hand, the production of the whole world before the war, excluding the United States, was less than 44,000,000 tons of ingots. Including material received from the United States the world got along with an amount of steel less than the present capacity of the United States. It was not a prodigal user of steel as the United States has been, and in that respect the comparison between steel capacity in this country and conditions outside this country is unfavorable.

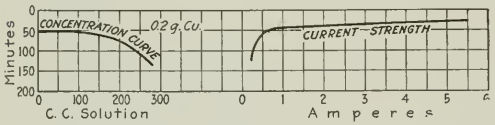
Readers' Views and Comments

Rapid Electrolytic Copper Assay Without Rotating Cathode

To the Editor of Chemical & Metallurgical Engineering

SIR:—Nearly all apparatus for electrolytic analysis on the market is equipped with a motor and revolving cathodes. This enables the agitating of the electrolyte while the metal is being deposited, and is a distinct advantage. The solution is stirred and fresh copper ions come in contact with the electrode continually. Also any hydrogen bubbles formed on the cathode are broken by the agitation, thus eliminating the danger of spongy copper being formed. Moreover, under these conditions, a very much higher current density can be used than otherwise would be possible and insteal of leaving your assay over night you have it done in a few minutes.

However, even without this elaborate equipment it is possible to perform this assay quickly if precisely the proper conditions are obtained. As chief chemist



for the Vermont Copper Co., at South Strafford, Vermont, I conducted a number of experiments along this line and the following was found to be the best method of procedure.

A sample on the ore was decomposed in 5 cc. each of HNO_3 and HCl, heated nearly to dryness, and then 5 cc. of H_2SO_4 was added and heat applied until SO_3 fumes were freely evolved. The residue was cooled, diluted, 1 cc. of HNO_3 added to break up the anhydrous ferrous sulphate, boiled, cooled and filtered to remove insoluble. The filtrate was then placed under the electrodes and the copper precipitated. After precipitation the cathode was washed in water and then in alcohol, and then burned over a free flame before weighing.

The Winkler type of cathode was used, which in this case was constructed of a cylinder of platinum gauze 3 cm. in diameter and 6 cm. in length. The gauze was composed of wires 0.06 mm. in diameter with forty-one meshes per linear centimeter. The anode used was simply a spiral of No. 16 platinum wire hung inside the cathode. With this arrangement rapid deposition was effected and no trouble with spongy deposits was encountered.

Another fact that facilitated rapid work was the quantity of solution used. The accompanying graph shows the result of a series of experiments. However, I found 100 cc. to be the minimum amount of solution I could use without having the solution so concentrated that it would dissolve up the copper faster than it was precipitated.

The other graph shows the result of varying the current strength. I believe the conclusions are self-evident.

The cost of making assays by this method was 30c. each. This figure includes cost of materials, labor, interest on cost of laboratory equipment, and depreciation.

RICHARD G. PLACE.

Acme Manganese Mining Co.,
Pasadena, Calif.

The Perchloric Acid Method for Potash in Cement Materials

To the Editor of Chemical & Metallurgical Engineering

SIR:—Since the almost prohibitive cost of platinum salts has made the determination of potash by the old method quite an expense to those who, like the cement chemists of to-day, have frequent occasion to determine K_2O, analysts have turned to other methods which may be substituted for that employing platinic chloride, and two are in common use, the cobalti-nitrite and the perchloric acid methods.

The former is held by many authorities to be unreliable and is also somewhat complicated, though it is capable of giving excellent results if carefully performed, but the perchloric acid method has lately sprung into prominence through the possibility of obtaining perchloric acid (60 per cent solution) in pure form at a reasonable price.

The manufacturers of this acid give directions for its use in potash determinations which are satisfactory as regards water-soluble potash, but they say nothing of the *modus operandi* when *total* potash is required, as it often is in such materials as shale, clay, flue dust, etc., which, being silicates in whole or part, require fusion before they can be brought into solution.

The writer has found that the determination of water-soluble potash by the perchloric acid method is simple, rapid and accurate. The substance is boiled half an hour with excess of water, filtered, and the filtrate acidified with HCl. Sulphates are precipitated as $BaSO_4$ and removed by filtration, and calcium is precipitated in the filtrate by ammonium carbonate and a little ammonium oxalate. These reagents are both volatile at a low heat, so that when the filtrate from the carbonate precipitate is evaporated and the residue moderately heated, ammonium salts pass off, leaving nothing remaining but chlorides of potash and soda. These salts are converted into perchlorates by a little perchloric acid and separated by alcohol, which dissolves the sodium perchlorate, but leaves the potassium perchlorate undissolved, and the latter can be readily collected on an asbestos filter and weighed.

The treatment of flue dust, etc., for total potash is necessarily more complex, but presents no difficulties. Of course, ordinary fusion with carbonates to break up the silicates is not permissible, as this would introduce large proportions of soda and probably some potash, which would obscure the result, so it is best to adhere to the J. Lawrence Smith fusion with ammonium chloride and calcium carbonate preferably in a long platinum crucible. After digestion of the charge in water the excess calcium carbonate is filtered off, the filtrate acidified with HCl and treated exactly as the first filtrate in the water-soluble determination.

The writer has found that most flue dust contains

organic matter which necessitates filtration after driving off the ammonia salts by heat, that is, before evaporating the solution of sodium and potassium chlorides with perchloric acid. Otherwise the operations for total and water-soluble potash are identical after the first solution is obtained. In detail the method employed in our laboratories is as follows:

For Total Potash. Grind ½ g. of the sample (flue dust, shale, etc.) with ½ g. ammonium chloride in an agate mortar. Add 4 g. of pure calcium carbonate and grind thoroughly together. Put a little calcium carbonate in bottom of J. Lawrence Smith crucible, add the charge with 1 g. calcium carbonate on top, cover and heat with a low flame till there is no further odor of ammonia (15 min.). The heat must not be high enough to permit the escape of visible fumes. Then raise the heat to moderate redness for 45 min., turning crucible occasionally. Cool, dissolve the melt in a little water, carefully rinsing the crucible. Slake on water bath, breaking up lumps. Filter off excess calcium carbonate, wash and make filtrate strongly acid with HCl. Boil and add slight excess of barium chloride. Let stand preferably several hours. Filter off the barium sulphate, wash, heat the filtrate to boiling and add ammonia till alkaline, and ammonium carbonate until no further precipitate forms. Add a few drops of ammonium oxalate, filter and wash. Evaporate the filtrate to dryness in a platinum dish and when dry heat carefully to just below redness till all ammonium chloride fumes are gone. Cool, dissolve in 25 cc. hot water, filter off anything undissolved and add to the filtrate enough 60 per cent perchloric acid solution to convert all the alkali metals into perchlorates (ordinarily 1 cc. is enough). Evaporate until nearly dry and when heavy fumes of $HClO_4$ appear cool, add 25 cc. hot water, another cc. perchloric acid and evaporate again to the same point. Cool, add 25 cc. wash alcohol (containing 1 cc. perchloric acid solution to every 300 cc.), filter on asbestos in a Gooch crucible, wash with the same alcohol, dry and weigh as $KClO_4$.

In washing the precipitates it is unnecessary to wash them entirely chlorine free; for ordinary work three or four washings are sufficient. The barium chloride, ammonium carbonate and ammonium oxalate mentioned are all used in saturated solutions.

For Water-Soluble Potash. Five grams of the sample are boiled 30 min. with 150 cc. water in a small flask with condensing tube. Cool. Make up to 250 cc., mix well and filter through a dry paper without washing. Take 50 cc. of the filtrate, corresponding to 1 g. of the sample, acidify strongly with HCl and proceed as in the determination of total potash given above. Multiply weight of potassium perchlorate found by 33.935 for per cent of K_2O in sample. WILLIAM B. NEWBERRY.

Sandusky Cement Co.,
Cleveland, Ohio.

Credit to Whom Credit Is Due

To the Editor of Chemical & Metallurgical Engineering

SIR:—I read, with great interest, an article in your issue of April 15 by the Messrs. H. E. and C. E. Hollister regarding the great acid plants of the Government powder plant, and it seems to me as if everybody comes in for some mention for his particular part in this great undertaking, from the lowly shoveler to the superintendent. But there is one branch with which I had the pleasure of being connected and which I know put forth its best efforts in connection with this work and seems to have been completely ignored. This branch was the resident engineers' department of the Thompson-Starrett Co. under Mr. A. E. Barlow, who supervised the entire field work of the areas mentioned in your article, and labored from sunrise to sunset, rain or shine, to lay out the work so that construction could be carried on. Mr. Geo. Uhden was the engineer directly in charge of Area "B" and Mr. Fred Petzold in Area "C."

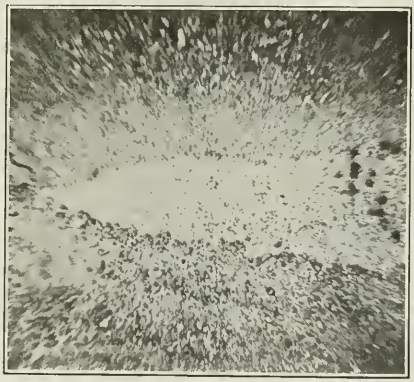
In justice to the above-mentioned branch of the organization and its members I think this letter should receive as much publicity through your columns as the article which so completely ignored them.

Brooklyn, N. Y. FRED PETZOLD.

Flakes in Steel

To the Editor of Chemical & Metallurgical Engineering

SIR:—In my paper on Flakes in Steel in your April 1 issue a correction should be made. On page 351 the phrase on line 34 from the top reads: "Another possible cause for flake may be segregated spots such as are exhibited by the variable-hued grains in Fig. 23."



This is wrong. The expression refers to a picture which was not reproduced and of which I enclose a copy. The variable hued grains in Fig. 23 do not, in my opinion, cause flakes. Fig. 25 shows the same kind of differently hued grains and is from a bar practically free from sign of flake. HAAKON STYRI.

Carnegie Institute of Technology,
Pittsburgh, Pa.

Bids Requested on Chlorine

Sealed proposals in duplicate addressed to Paints Branch, Raw Materials Division, Munitions Bldg., Washington, D. C., are desired on 6500 lb. of liquid chlorine, bidders to specify size of container and quote price f.o.b. Camp Merritt, N. J.

Standard Form for Mexican Claims

The State Department at Washington announces that a standard form has been prepared for filing claims against the Mexican Government. It is expected that the final form will be prepared for approval by the middle of May, at which time copies will be sent to those who have claims in order that they may be resubmitted. The new form will supersede all previous ones.

Western Chemical and Metallurgical Field

Cost of Quicksilver and Fulminate

ANY attempt to estimate the cost of metal production is likely to be misleading, since conditions vary so much from district to district, while even with identical mining and metallurgical practice and efficiency, the cost per unit varies immensely with the tenor of the ore. F. C. Ransome, in a recently issued Geological Survey publication on quicksilver, has estimated the labor required to produce mercury in American mines during 1917 as follows:

RELATIONS OF QUICKSILVER PRODUCTION TO LABOR IN CALIFORNIA AND TEXAS

	California		Texas,
	All Mines	Eight Leading Mines	Three Mines
Ore treated, short tons	235,786	203,449	26,802
Quicksilver produced, flasks	23,938	18,581	10,530
Tenor won	0.38	0.34	1.47
Average number of men employed	950	715	253
Man-days of work	310,500	233,689	84,795
Quantity of ore treated per man, short tons	248.1	322.8	105.9
Quantity of ore treated per man-day, short tons	0.75	0.99	0.32
Quicksilver obtained per man annually, flasks	25.1	26.0	41.6
Quicksilver obtained per man-day, flasks	0.077	0.079	0.124

On this basis he estimates that in 1917 the average cost, including development and amortization, of producing a 75-lb. flask of mercury in California from 0.38 per cent ore was from $65 to $70. The cost in Texas was lower, due to its average content of 1.43 per cent. Spanish mines in Almaden made $12 quicksilver from 9.04 per cent ore in 1915. Monte Amiata in Italy produced mercury for about $30 in 1913 from 0.89 per cent ore, while the pre-war cost at Idria, Austria, was $23 per flask from 0.65 per cent ore.

While the foregoing figures are as of 1917, it is entirely safe to assume that costs of production in California and Texas have not dropped in the meantime, so with the present San Francisco price of $70 per flask it is easy to understand the closure of some California quicksilver mines and the curtailment of operations of others. During the war the developed ore reserves and ore dump were nearly exhausted. Mexican importations amounted to about 250 flasks in February of this year. While unrestricted competition with Mexican and Spanish mercury would make the continuance of the American industry dubious, material importations from Mexico are contingent upon stabilization of their uncertain internal affairs, while shipping capacity is still so largely engaged in post-war activities that large quantities of European metal may not arrive for some months.

As noted in our issue for Sept. 1, 1918 (p. 240), about one-third the American production and consumption is absorbed in drugs, chemicals and dental amalgams. An equal part was expected to be used by the ordnance departments for fulminate—$Hg(CNO)_2$—in detonating high explosives. Owing to the high cost and scarcity of mercury and the tremendously expanded use of fulminate, many efforts were made to substitute other compounds in whole or in part. This was only partially successful, however, owing somewhat to the uncertainty of action of the substitutes, and their high cost. In other words, during 1918 a prominent detonator manufacturer stated that straight fulminate from $100 mercury was probably cheaper than the then available substitutes. Fulminate is often combined with other substances, particularly with an abrasive, such as powdered glass, to increase its sensitiveness, and with compounds or mixtures that themselves have the property of detonating, such as sulphide of antimony and chlorate of potassium. Recently a large part of the mercury fulminate in detonators has been replaced by picric acid, trinitrotoluene, or tetranitromethylamine, according to Walter Arthur, whereby a much stronger initial effect is obtained and one part of mercury fulminate is made to detonate a charge that would have required six times as much fulminate used alone. Other substances have been found also which seem likely to replace mercury fulminate entirely for certain uses. One of these is lead azide, a salt of hydronitric acid. Large dry crystals of this salt are so sensitive as to explode when brushed with a feather, but smaller crystals are less sensitive. Other proposed substitutes are lead styphnate, $PbC_6(NO_2)_2O_2$; hexamethylamine triperoxidediamine, $N(CH_2O.OH_2)_3N$, said to be four or five times as strong as mercury fulminate; nitrogen tetrasulphide, N_2S_4; diazobenzolnitrate, $C_6H_5N_2(NO_3)$; basic mercury nitromethane; and perchlorate of trimercuraldehyde.

Minerals Relief Commission

The organization of the commission for the settlement of the net losses sustained by the producers of manganese, chromium, pyrite and tungsten has been completed. The members of the commission are John F. Shafroth, Chairman; M. D. Foster and Philip N. Moore. The commission's headquarters is Room 2131, Interior Department Building, Washington, D. C. Under the procedure established by the commission a questionnaire is sent out to the claimant, and when this questionnaire is returned, the facts which it presents form the basis for determining what further examination of the claim is warranted. The verification of facts and the field examination of mines is being carried out by the Bureau of Mines, when such examination is requested by the commission, but the commission has entire authority in making awards.

Vancouver Conference

A well-attended conference of Western mining men was held in Vancouver, B. C., during March, at which some interesting discussions were held. At the end all the members were urged to lend their efforts toward the initiation and support of a modest iron and steel industry near the international boundary, Prof. Stansfield having reported the venture as metallurgically feasible, and Minister of Mines Sloan having declared that British Columbia possessed the ore in proper quantity and quality.

A resolution interesting to metallurgists was adopted, calling for the abolishment of the fixed price for silver. From the producer's standpoint, fixed prices sometimes appear good and sometimes bad—American farmers, for instance, do not seem to resent the fixed price for wheat. On the other hand, most of the men present at the Vancouver conference were sure that in a free market the price of silver would advance to at least $1.20 per oz., due to the demands for coinage to replace the metal hoarded by subjects of Eastern governments which are in various stages of instability.

Sydney Norman, Editor of *Northwest Mining Truth*, in a plea for government control of smelters, called attention to the absence of cordial relations between

smelters and miners which appears everywhere, and which has been subject of comment for years. The smelters contend that their rates are as low as good business will permit, while the miners feel they are not getting a fair share of the returns. The speaker argued that if the rates really are correct, the smelters should not object to an impartial regulation, especially since it would remove that popular discontent and distrust which leads to a demand for outright government ownership. He also declared that in return for such regulation the British Columbian government would be justified in subsidizing the operation of a tide-water smelter and refinery to such an extent as would be necessary to insure a good volume of ore supply.

Copper Production and Price

An editorial in CHEMICAL & METALLURGICAL ENGINEERING for Feb. 15, 1919, noted the fact that wages in copper mines, mills and smelters were generally reduced on Feb. 1, to correspond approximately with the declining metal market. A number of minor labor disturbances followed, which were fortunately of short duration—even a well-advertised I. W. W. demonstration in Butte being only a flash in the pan. The steadier heads among copper operatives realized that this is only another trough in the fluctuations in the copper world, and have learned to accept, with considerable equanimity, these recurrences of slack times.

The present rate of production is rather hard to estimate. Ten large properties in February hoisted 65 per cent of their output for the preceding October. These companies have accumulated a considerable cash reserve and are able to finance a large unsold stock, while their costs, when sheared of such items as depreciation and depletion allowed on income tax returns, are still at or below the present market price.

Many smaller producers, whose aggregate output is very considerable, are not so well circumstanced, however, and have shut down entirely, or are merely holding a skeleton crew on repairs and development.

Supposing the total U. S. smelter production at the present writing to be but 50 per cent that of the 1918 rate, it would amount to 955,000,000 lb. per year, which is still equal to 83 per cent of the production of 1914 (a rather slack year). Bearing in mind the accumulated stocks of copper on hand of over a billion pounds which must be absorbed, the dislocation of industry and its impaired buying power, and the present greatly reduced export demand, it is apparent that courageous convictions as to the near future must be held by the leaders of the copper industry.

In view of the "buy now—never mind the price" propaganda of American industries in general, it is refreshing to view the old-fashioned methods used by copper men to stimulate demand. They had large quantities to sell and used the best and most reasonable method—they cut the price to a point where purchasers who needed it became interested. Buying at 14½ to 15c. was so well sustained that a moderate rise in price has since been recorded, visible stocks for sale are at least not growing, and any intending purchasers of the red metal do not need a "price guarantee." Were the inflated prices of foodstuffs, clothing, steel products, manufactured articles and other necessities of private and industrial life to approach pre-war normals with as little disturbance to labor rates as have the copper quotations, industrial activity and expansion would have its biggest obstacle removed.

Symposium on Pyrometry at Fall Meeting of A. I. M. E.

ONE of the features of the meeting of the American Institute of Mining and Metallurgiacl Engineering to be held in Chicago next September is a symposium on pyrometry which is being prepared by a special committee of which Paul D. Foote, Bureau of Standards, Washington, D. C., is secretary. Thus far 20 papers have been promised. The program of the symposium will have the following scope:

I. Methods of pyrometry.
  1. Thermo-electric pyrometry.
  2. Resistance thermometry.
  3. Optical and radiation pyrometry.
  4. Seger cones and veritas firing rings, etc.
  5. Standardization and testing of pyrometers.
  6. Recording pyrometry.
  7. Automatic, semi-automatic and manual signal and temperature control.

II. Industrial pyrometry.
  1. Pyrometry in the metallurgical industries.
    (a) Pyrometry and steel manufacture.
    (b) Heat treatment and forging of steel.
    (c) Pyrometry in the non-ferrous foundry.
    (d) Pyrometry and industrial heating furnaces.
  2. Pyrometry in the chemical industries.
  3. Pyrometry in the ceramic industries.
    (a) Pyrometer porcelains and refractories.
  4. Pyrometry and glass manufacture.
    (a) Plate glass.
    (b) Bottle glass and general chemical glassware.
    (c) Optical glass.
  5. Pyrometry and gas manufacture.
  6. Pyrometry and coke manufacture.

III. Pyrometry and its relation to science.
  1. High temperature scale.
  2. Melting points of metals and refractories.
  3. Precision optical pyrometry.
  4. Optical pyrometry and illuminating engineering.
  5. Fundamental constants of pyrometry.
  6. The teaching of pyrometry in our technical schools.

Use for Surplus TNT

All surplus TNT and other explosives owned by the War Department which can be used in clearing land, building roads, general construction work or in any way as a substitute for the ordinary commercial dynamite have been turned over to the Department of Interior. These explosives will be used on public works, and a portion may be used for the clearing of lands for honorably discharged soldiers, provided a soldiers' settlement bill is passed by the next Congress. This material, which at one time was considered practically worthless, now has an estimated value of $15,000,000. There will be no public sale of explosives by the Army, and if any surplus of this material is found in the future, it is thought that it can be used by the Department of Interior.

Imports of Tungsten-Bearing Ore

The Division of Statistics, Bureau of Foreign and Domestic Commerce, of the United States Department of Commerce reports the following imports of tungsten-bearing ore and exports of tungsten and ferro-tungsten metal for February, 1919:

IMPORTS OF TUNGSTEN-BEARING ORE, BY COUNTRIES, AND EXPORTS OF TUNGSTEN AND FERRO-TUNGSTEN METAL, BY COUNTRIES

	Imports			Imports	
Countries	Tons	Value	Countries	Tons	Value
Panama	0	$172	Japan	451	$645,886
Bolivia	14	9,984			
Chile	63	88,080	Total	1,535	$1,810,864
Peru	60	62,752			
China	424	442,626		Exports	
Chosen	46	58,375	Countries	Pounds	Value
Hongkong	477	502,989	Canada	30	$137

Import License Proposed

SPEAKING before the National Cotton Manufacturers' Association on April 25, Francis P. Garvan, Alien Property Custodian, declaring that it is necessary that Congress adopt an import license system, said:

"The Chemical Foundation proposes to place all possible information on our situation before Congress, and ask the passage of a law establishing a license system governing all chemical importations for a period of ten years. It is intended that this license system shall act at one and the same time as a guarantee to you and all other dependent industries proper importations to enable you to meet the competition of other lands, and to protect and guard our growing chemical independence. In this we ask no more than England, France, Italy and Japan already have decided to grant on behalf of their own independence. This request we base upon the following grounds:

1. Fairness to the $500,000,000 invested by loyal Americans in the hour of our need.
2. Independence and freedom of the textile, leather, paper, paint and varnish, pharmaceutical $3,000,000,000 essential American business.
3. The necessity of our national defense.
4. The destruction and prevention of the German system of propaganda and espionage in our land.
5. The advancement of pure science and research.
6. The advancement of medical science.

"The granting of this license system is not a question of conflicting economic schools. It is the question of our national independence, safety and education.

"Once we are assured time in which to work out our salvation we hope to turn to our dearest objective. Already we have started to make a survey of our laboratory equipment—governmental, university and factory. Already company after company has passed resolutions through their boards of directors placing at the disposal of our trustees, under such terms and conditions as those trustees may dictate, their entire research capacity. Government laboratories and university laboratories also have been assured us. Gentlemen, we know that offer will be unanimous.

"We soon will be able to go to the medical profession of America and offer to them the entire capacity of the country for experiment and research for the betterment of mankind. One medical chemist in one dye factory in Germany discovered the cure for syphilis, the deadliest enemy of mankind. The same medical chemist, in the same dye factory, discovered the cure for the sleeping sickness of Africa which made a continent habitable. What can we not hope for when the American medical profession is given unbounded scope and opportunity?

"We are assured that somewhere within that realm lies the hope of the cure for consumption, cancer and many of the seizures which rob us of our little ones. Can it be that herein lies the opportunity of converting the forces which up to now have been directed only toward desolation and destruction into the channels of alleviation and helpfulness to humanity? Can it be that through this medium idealist America may snatch the torch of misapplied science from the barbarian, and place it in the hands of an enlightened civilization?

"Gentlemen, Drs. Albert and Bernstorff reported to their government that America never could establish the dye and pharmaceutical industry in this country, as we lacked the moral power for the creation of such an industry, that here each party pursued its own selfish interests, but nobody kept the whole in mind; that this problem could be solved only through regard for all points of view, and that the conflicting selfishness of this country rendered that solution impossible.

"The Chemical Foundation answers this statement with a challenge, and if it can become only the co-ordinating forum for American patriotism, American sacrifice and American ability, it awaits the issue with serenity."

Merck Stock to Be Auctioned

There will be a sale of 8,000 shares of the capital stock of Merck & Co., drug and chemical manufacturers, to the highest bidder at public auction at 11 a. m., Friday, May 9, when the shares in question will be offered by the Alien Property Custodian, Francis P. Garvan, who has possession of them by virtue of their having been delivered to him voluntarily by Mr. Merck in order that the question of their ultimate ownership might be settled. The shares represent 80 per cent of the total authorized and outstanding issue of 10,000 shares of capital stock having a par value of $100 each.

The company has its principal administrative offices at 45 Park place, New York City, where the bids will be received by Mr. Joseph F. Guffey, Director of Sales, A. P. C. office, and branch offices at St. Louis, Mo., and Montreal, Canada. Its principal plant is at Rahway, N. J., where 150 acres of land are occupied by the various buildings, the total area under roof being placed at 20 acres. This plant has been greatly enlarged since 1914. The company also has a small plant at Midland, Mich., within the Dow Works.

The New Jersey Chemical Society Spring Meeting

The New Jersey Chemical Society will hold its Spring invitation meeting in the Chemical Building, Rutgers College, New Brunswick, N. J., Saturday, May 10, 1919. Dinner will be served in the University dining hall at 7 p.m.

The program for the evening includes: "Address of Welcome," by Dr. W. H. S. Demarest, president of Rutgers College; "Stability of Automobile Engine Oils," by J. V. Meigs of Montclair, N. J.; "Oxidation and Reduction," with demonstrations, by Ernest Little, professor of chemistry; "Chemical Reactions Among the Lower Animals Causing Evolution of New Species," with stereopticon views, by Daniel R. Hodgdon, director of the Newark Technical College, Newark, N. J.

Information concerning membership and invitations for the Spring meeting in May can be obtained from Mr. H. C. Cawley, secretary, 256 Vanderpool St., Newark, N. J.

American Bureau of Welding

At a meeting of the American Bureau of Welding held on April 11, at the Engineering Societies Building, 33 West 39th St., New York, the by-laws of the bureau were adopted and the following officers elected:

Director, C. A. Adams; vice-director, H. M. Hobart; vice-director, A. S. Kinsey; treasurer, W. E. Symons; secretary, H. C. Forbes.

Regular meetings of the Bureau are to be held on the third Friday of each month.

The Bureau voted to establish a Research Committee for the purpose of carrying out the plan of co-operation in conducting investigations in welding.

A committee of 52 members has been appointed.

"Hamlet" With Hamlet Left Out

THE New York Section of the Society of Chemical Industry had a meeting of unusual interest on April 18, by making the most of what threatened to be a disappointment. The paper for the evening was announced as by two authors of eminent authority whose names are well known as a guaranty of scholarship and sound practice. Preceding the paper was the presentation of two portraits to the Chemists' Club in the hall of which the meeting was held. In the absence of Major Charles E. Sholes, the honorary chairman, Dr. Parker C. McIlhiney presided, and after a short delay the meeting began. The delay was caused by the absence of both the authors of the paper of the evening, whose arrival was expected every minute. After the usual preliminaries Dr. McIlhiney called upon Dr. W. H. Nichols, president of the American Chemical Society, to make the presentation on behalf of the General Chemical Co. and the Nichols Copper Co. of the portrait of Mr. J. B. Francis Herreshoff, who received the first Perkin Medal eleven years ago.[1] He told of his start fifty years ago in the chemical business, making 66 deg. B. sulphuric acid at Laurel Hill, of his partner Mr. Walter, and their one hired man who constituted the proletariat.

At this time the petroleum refiners began to use large quantities of 66 deg. acid for the clarification of oil. It was due to the ability of Dr. Nichols' works to make dependable delivery at this concentration and not just approach the neighborhood of 65 deg. or thereabouts that the first great acid market—that of the ever growing American petroleum industry—was secured for the coming General Chemical Co. An important commercial feature, which was first observed by Mr. Herreshoff, was that acid which had been concentrated to 66 deg. could be shipped in steel drums or tank cars.

Up to his untimely death at sea while en route to Germany, Mr. Walter had been the business man, and Mr. Nichols the scientist. It now became Mr. Nichols' province to attend to the firm's business affairs, and when young Herreshoff, who, though a sophomore, had been teaching seniors chemistry at Brown University, applied for a position, he took him on. They were all young except the hired man and the competitors, and of the latter a number of kindly elder men cautioned young manager Nichols against the danger of taking such a theorist, fresh from teaching in a college, into his factory. He would surely live to rue the day, they said. Dr. Nichols confessed to a certain measure of stubbornness in the matter, with the result that the same theorist and he have been working together ever since. At this point he admitted that he was talking against time, in the hope of seeing the appearance of one of the authors of the paper on the program; but neither arrived.

Then followed reminiscences in connection with making sulphuric acid and another enterprise that was also certain, according to the advice of practical men, to end in ruin. This was no less than the purchase of a copper mine with sulphur-bearing ore which nobody else wanted. When Herreshoff had mastered the roasting problem, they thought they had a good thing, and saw no reason why they might not turn an honest penny by royalties; but again they were scorned for their youth and inexperience in the metallurgical methods of the day by the old timers both here and abroad. Then followed intimate details of technical problems and business turns, as romantic as any knights' adventures; the beginning of the electrolytic refining of copper, the reason why they were driven to it in order to maintain their independence, the quick response of Herreshoff in shifting laboratory scale operations to meet plant requirements and the organization of the Nichols Copper Co., all worth a long journey to hear.

Professor Chandler followed, presenting on behalf of Mrs. Acheson a portrait of her husband, Dr. E. G. Acheson, Perkin Medalist for 1910[2], and here again was a good story. There was the beginning with Thomas A. Edison and his work on the carbon filament, and finally Dr. Acheson's independent work resulting in carborundum and artificial graphite. It was a neatly turned biography with romance in it, all presented in Dr. Chandler's happiest style.

President Hendrick on behalf of the club received with a few remarks the two portraits that had just been unveiled by the previous speakers—but it was not given to him to kill time. Owing to the provisions of the constitution and by-laws of the club and the approaching annual meeting, there was a trustees' meeting called for the same evening, and it behooved them to convene in their room to get through with certain measures of important business.

It was still, however, merely the shank of the evening, but a little after 9 o'clock; and Chairman Dr. McIlhiney had his audience, but nobody to present a leading paper. So he called on Dr. Herreshoff, who reviewed in an intimate and informal manner many of the vicissitudes which he had met along the way, and after he had finished Dr. Acheson, who is ordinarily as shy as a girl about talking in public, was induced to take the platform, and he told his experiences with the same freedom as his predecessors.

At seventeen years of age, Mr. Acheson decided to become a chemist. His father had a small foundry near Pittsburgh and sent samples of coke and iron there to the laboratory of Otto Wood for analysis more or less regularly. Feeling that a very practical way to get a chemical education would be through Wood, young Acheson went to Pittsburgh filled with great hopes for his future. To his surprise, Wood's advice was "Don't become a chemist. It's a humdrum life with no prospects, etc." Undoubtedly it is fortunate for so keen a mind as that possessed by our inventor of electrothermal products of the carbosilicon series that he drifted around until he landed in Mr. Edison's keeping at Menlo Park. The subsequent events[3] are too well known to our readers to be described here in detail. Mr. Acheson mentioned his present research on colloidal deflocculation with graphite and clay. He has been able to produce perfectly translucent solutions of these materials, which are so finely divided that they have excited the admiration of the foremost ultramicroscope investigators.

It was just as though those present had been sitting in the club about a cosy fire, while W. H. Nichols, J. B. F. Herreshoff and E. G. Acheson had each opened up, and told, as among friends, his experiences in applied chemistry, with a delightful little talk by the fine old dean of American chemists added to it. It was a memorable occasion.

[1] *Electrochemical and Metallurgical Industry*, Feb., 1908, Vol. VI, p. 51.

[2] METALLURGICAL & CHEMICAL ENGINEERING, Feb., 1910, Vol. VIII, p. 69.

[3] *Electrochemical Industry*, Vol. I, p. 90, Nov., 1902.

Metallic Coatings for Rust-Proofing Iron and Steel—I

A Concise Account of the Nature of Corrosion, Rust-Proofing Metal Coatings, With Recommendations, Is Given—Description and Comparative Values of Different Methods of Testing Coatings, Especially of Zinc

By HENRY S. RAWDON,[1] M. A. GROSSMAN[2] and A. N. FINN[3]

THE study of the deterioration of iron and steel, particularly by corrosion, and the means for mitigating the same, has probably received more attention, and properly so, than any other phase in the study of steel. In the following article, the experimental results, when given, have been taken from the results of the numerous examinations and tests of materials submitted to the Bureau of Standards during the past few years. The general and more descriptive portions have been summarized after a careful review of the most helpful articles in the literature on the subject of corrosion, which is extremely voluminous.

I. Introduction

1. General Nature of Corrosion

Various theories have been advanced concerning the nature of the process of the corrosion of iron, and a vast amount of experimental work has been done to support these theories. All agree, however, that the process is electrolytic in its nature, and the various hypotheses differ only as to the factors by which the electrolytic action is brought about. Iron and steel will not corrode in dry air—the presence of moisture is an essential condition, and according to one of the theories, carbon dioxide must also be present. Protection from atmospheric corrosion may be afforded in two ways; first, by mechanically excluding all moisture and other corroding agents from the iron and steel, and, second, by using coatings of such a chemical nature that the covering itself is corroded in preference to the iron or steel beneath. It must be remembered that all "rust-proofing processes" are temporary only in character; some, however, are so far superior to others that the use of the term "rust-proofed" is justifiable in such cases.

The attempt to prolong the life of iron and steel parts in service by protecting them against corrosion has led to the adoption of many materials and processes for coating. The protective materials fall in general into three classes: (1) The metallic coatings, (2) the coatings in which the iron to be protected is itself converted at the surface into some less corrodible compound, and (3) the organic coatings, including paints, varnishes, enamels, etc. The metallic coatings include all the common metals and alloys that can be applied at all readily to steel, namely, zinc and aluminium, which are electro-positive to iron (as explained below), and tin, lead, "terne" and other lead alloys, copper, nickel, cobalt, brass, bronze and silver, all of which are electro-negative to iron. In the case of the iron compounds, the iron at the surface is converted to oxide or to some other compound and the piece is then usually given an oil finish. The organic coatings will not be discussed in this article.

2. Principles Underlying Methods of Prevention

Of the metallic coatings, the best, by far, for general rust-proofing is zinc. The principal reason for this lies in the chemical nature of zinc—it is the only one of the commonly used metals that is electro-positive to iron, that is, it has a greater tendency to be oxidized than has iron. In the following table the metallic elements are arranged in their proper order in the potential series. Any element is electro-positive to any element following and electro-negative to any element preceding it in the table:

POTENTIAL SERIES

K	Potassium	Fe	Iron	Cu	Copper
Na	Sodium	Cd	Cadmium	As	Arsenic
Ba	Barium	Tl	Thallium	Bi	Bismuth
Sr	Strontium	Co	Cobalt	Sb	Antimony
Ca	Calcium	Ni	Nickel	Hg	Mercury
Mg	Magnesium	Sn	Tin	Ag	Silver
Al	Aluminum	Pb	Lead	Pt	Platinum
Mn	Manganese	H	Hydrogen	Au	Gold
Zn	Zinc				

When any steel article with a metallic coating is scratched or abraded so that a small area of the steel is exposed, the two dissimalar metals together with a small amount of moisture derived from the atmosphere will form a tiny galvanic cell, set up a current and start corrosion. That metal which is electro-positive to the other will be the one to be oxidized, while the electro-negative metal will remain uncorroded. So if the coating metal is zinc, it is zinc that will be oxidized, while the iron remains bright and uncorroded until the "bare" spot becomes so large that the central portion is beyond the "protective zone" of the surrounding zinc. On the other hand, should the coating happen to be tin, which is electro-negative to iron, it would be the steel that would suffer. In such a case, the tin coating is actually injurious, because without it the steel would oxidize at the normal rate, with no galvanic action to hasten the corrosion. The value of tin for coatings depends upon other factors than its electrochemical nature.

Zinc, then, has the advantage of being electro-positive to iron and so preventing its corrosion, especially on small exposed areas such as "pin-holes" in the coating, scratches, etc. One other common metal, aluminium, is also electro-positive to iron, but does not share the other advantages enjoyed by zinc, such as relatively low cost, the ease with which it can be applied to steel in quite a number of ways, and the fact that with a little care it will solder readily. (Refs. 1-11 inc.)

II. Types of Coatings and Methods of Application

1. Metallic Coatings

a. Zinc. The oldest process for zincing or galvanizing, and the one most widely used, is the hot-dipping process, in which the steel, after a preliminary cleaning

[1]Asso. Physicist (Metallography), Bur. of Standards.
[2]Metallographist, Vanadium Co. of America.
[3]Asso. Chemist, Bur. of Standards.

of the surface, is immersed in molten zinc, left in the bath long enough for the steel to reach the temperature of the zinc and then withdrawn with the coating of zinc adhering to it (24, 25, 26, 27). It is a simple process and gives excellent results on smooth surfaces. In general, a piece of steel that has been zinc-coated by the proper hot-dipping method will be well protected against corrosion even under severe conditions of exposure.

Sherardizing

Another method of zincing, called sherardizing, consists in heating the steel in a so-called "zinc vapor" atmosphere. The steel parts are packed in a revolving drum with zinc dust containing a small amount of zinc oxide, and heated at 350 to 375 deg. C. (28, 29, 30, 31, 32, 33, 34). The cylinder is made to rotate slowly on its axis to tumble the parts and insure evenness of coating. Usually 3½ to 4 hours' heating is required to produce a satisfactory coating.

Zinc is also applied to steel by plating from an aqueous solution (36, 37, 38, 39, 40). Those commonly used are either a solution of zinc sulphate containing a small amount of free acid or a solution of zinc cyanide or one of zinc oxide in a mixture of sodium cyanide and sodium hydroxide. The plating usually takes from a half-hour to an hour, but may be continued longer to produce very heavy deposits.

There are other methods of applying zinc which are used less often. The Schoop spray gun, for example, is a device for spraying molten metal upon an article to be coated (41, 42, 43, 44). The zinc, in the form of wire, is fed into the spray gun, where an oxy-acetylene flame melts it, and a strong current of air projects it from the nozzle in the form of a very fine spray, which is directed against the steel. In another process, called "epicassit," the zinc, in the form of filings, is mixed with a flux, made into a paste and then painted on the steel (45). The article is then heated until the zinc just melts, making a continuous adherent coating.

Advantages and Disadvantages of Each Type

Of the three forms of "zincing" most commonly used, namely, hot-dipping, sherardizing and electroplating, each type has its advantages and its disadvantages. Hot-dipping is excellent for even surfaces, as it gives a heavy coating in a very short time. The thickness of coating on such material as sheets and wires can be easily regulated by "wiping" and other mechanical devices; on irregular shaped articles, however, there is no simple way of regulating the amount of zinc used. This method cannot be used on accurately machined parts, such as screw threads, for obviously the zinc would collect in sharp corners and alter the original outlines of the piece. Neither can it be used on a highly hardened steel where the heating to 450 deg. C. (the approximate temperature of the zinc bath) would soften the steel too much for its intended use.

Sherardizing has the advantage of giving very even coatings. The coating on a screw thread, for example, will show no appreciable variation from the top to the root of the thread. On the other hand, sherardizing is a slower process, and it cannot be used on such hardened steels as would be softened too much by heating at 375 deg. C. for 3 to 4 hours. Neither is the method suited to handling large sheets, etc. Furthermore, the quality of coating produced by this method is greatly modified by the conditions of operation, such as purity of the zinc dust, uniformity of heating, duration of treatment, so that widely different results are obtained in practice.

Electroplating has the advantage of being readily applied to small and delicate articles that are not easily handled in other ways, and the obvious advantage that it can be applied to steel without modifying any previous heat treatment. One advantage of this process is the ease of operation; there are several devices now upon the market by means of which the operation (including the preliminary cleaning and final washing) can be made a continuous one requiring but little supervision. Another distinct advantage of electroplating is the ease of control of the thickness of the deposit—within rather wide limits this is directly proportional to the period of deposition. On parts having sharp corners or depressions, however, it is apt to give uneven coatings. On threads, for example, there will be an accumulation of zinc at the top of the thread, while the root may be nearly bare, and even on flat plates it has been found that the coating is heavier at the edges than in the center. It seems probable, however, from some recent work done by this Bureau, that such differences are much less pronounced in zinc deposited from the cyanide solution than in that from the sulphate bath.

b. Aluminium. Aluminium has never been used commercially on a large scale for rust-proofing, on account of the difficulty of applying it to steel. Aluminium is electro-positive to iron, and would, therefore, make a good protective coating. One method of applying it, called "calorizing" (46, 47), is somewhat similar to sherardizing, in that the steel is packed in a mixture containing powdered aluminium and heated at 900 to 950 deg. C. This process is used commercially to a limited extent.

2. Soft, Fusible Metals (Tin, Lead and Their Alloys)

Almost all of the metallic coatings other than zinc and aluminium divide naturally into two chasses, the soft low-melting-point ones and the hard metals with relatively high fusion points. Those in the easily fusible class, such as tin, lead and their alloys, are applied almost altogether by hot-dipping. Those not so readily fused, such as copper, nickel, cobalt, silver, brass, etc., are for the most part electroplated.

One of the most widely used of the coating metals is tin. It is in the class of metals that are electro-negative to iron, so that a tin coating must be free of pin-holes and must not be abraded or injured, or accelerated corrosion will set in where the steel base is exposed. However, the tin itself corrodes very slowly, and it has several advantages in that it is applied very easily by hot-dipping, is soldered more readily than any other coating and has the further very important advantage of having no toxic effect, so that it can be used in food-containers. Hot-dipping is used for the large majority of tinned articles, but the metal may also be applied by the Schoop spray and by plating (51, 52, 53).

Lead alloys are applied by quite the same processes as is tin, but they lack some of the advantages of tin. Lead does not solder so readily because it oxidizes quickly when heated, but it is much cheaper than tin, and has been used especially in terne, which is an alloy of about ¾ lead and ¼ tin. The electrodeposition of

lead for the production of protective coatings has recently come into commercial use. Lead, however, is electro-negative to iron and has the corresponding defects (54).

3. Hard Metals (Copper, Nickel, Cobalt and Brass)

Copper has been used a great deal for rust-proofing. Metallic copper itself corrodes very slowly, and it has found such wide application largely because it is applied very readily by electroplating. But it is electro-negative to iron, so the coating must be well applied and be free of bare spots and pin-holes to protect completely against corrosion. A practice that is fairly common is the buffing of coppered parts to give a bright finish; this renders the coating more uniform in thickness and covers up such imperfections as pin-holes, etc. If the coating as deposited is very thin, however, severe buffing will remove it almost entirely in places and so accelerate corrosion.

In addition to electroplating, copper is applied with the Schoop spray gun, and by the so-called "copper-clad" process (49, 50). In the latter, copper is cast around a steel billet, and the billet rolled down to rod or sheet form. Copper so applied is less likely to be porous than is the case with electroplated or sprayed metal. The process of depositing zinc-coatings designated as "epicassit" has been modified for use in copper plating. The process is now being used industrially to a very limited extent (48).

Use of Nickel

Nickel is used for articles that are to have a light color, especially if a bright polish is desired. Most nickel is applied by electroplating, but it can also be applied by a process similar to the "copper-clad" process. Nickel is another one of the elements electro-negative to iron, although, being quite close to iron in the electro-chemical scale, its injurious effect is likely to be a little less pronounced.

Cobalt is quite similar to nickel in its properties, and is used in much the same way.

The electrodeposition of brass upon steel can be carried out with success and is used extensively on small articles such as builders' hardware, lighting fixtures, etc. It is plated from a solution containing both copper and zinc. It has no peculiar advantages as regards rust-proofing, but the brass color is sometimes desired. Brass has also been applied as in copper-clad and nickel-clad products, as has also bronze.

4. Oxides and Salts of Iron

a. Oxides. The oxide coatings on iron and steel are in general prepared by heating the metal in a suitable atmosphere or by oxidizing in the presence of certain aqueous or fused chemical reagents. Repeated alternate heatings in oxidizing and reducing gases give a comparatively heavy coating of black iron oxide, considered to be FeO. The etching and "coloring" processes (55) give thinner coatings, usually of a lower order of resistance to corrosion. The oxide coatings are always oiled, and undoubtedly owe some of their rust-resistance to this fact (56).

(1) *Bower-Barff Type.* The original Bower-Barff method consisted in heating the steel at 350 deg. C. and above, in air or sometimes in the presence of superheated steam; when a coating of ferric oxide had been formed, hydrocarbons were introduced which served to reduce the ferric oxide, Fe_2O_3, to ferroso-ferric oxide, Fe_3O_4. This process and the variations of it give a coating which offers a very fair degree of resistance to corrosion. One modern variation which is used extensively consists in heating at a low red heat in a mixture of steam and benzine. The modifications of the Bower-Barff process are known under quite a number of names, e.g., the Swann, the Bontempi (58), the Gesner, the Weigelin, etc.

(2) *Heating With Oil, etc.* In this type of process, the steel is heated in volatilized oil or in a thick, smoky atmosphere, whereby a deep black oxide coating is produced. The Carbonia process is typical, in which the steel is heated at about 220 deg. C. in a mixture of burnt bone and oil. In other processes the steel is heated in burnt bone and charcoal, or in oil and sawdust. The steel may also be oiled first and then heated to a temperature ranging from 300 to 550 deg. C. The process of "blacking" in a forge is similar: the steel is cleaned of loosely adherent scale and then held while quite hot in the thick smoky flame from the forge.

(3) *Etching ("Browning," "Bluing," etc.).* Solutions of chemical reagents are applied to the steel with a cloth or sponge, the steel is allowed to oxidize for some hours while drying; the rust is then scraped off, leaving a thin adherent coat of oxide. The process is repeated a number of times, depending on the depth of color desired. The surface is then oiled. The following is a representative list of combinations of reagents that have been used for producing the respective colors:

	(Pts. by Wt.)
BLACK	
Bismuth chloride	20
Mercuric chloride	40
Copper chloride	20
Hydrochloric acid	120
Alcohol	100
Water	1,000
Copper nitrate solution (10 per cent)	700
Alcohol	300
Mercuric chloride	50
Ammonium chloride	50
Water	1,000
BROWN	
Alcohol	45
Iron chloride solution	45
Mercuric chloride	45
Sweet spirits of niter (ethyl nitrite + alcohol)	45
Copper sulphate	30
Nitric acid	22
Water	1,000
Nitric acid	70
Alcohol	140
Copper sulphate	280
Iron filings	10
Water	1,000
BLUE	
Iron chloride	400
Antimony chloride	400
Gallic acid	200
Water	1,000
BRONZE	
Manganese nitrate solution (10 per cent)	700
Alcohol	300

(4) *Niter Bath.* The cleaned steel is heated in fused sodium nitrate or potassium nitrate, or a mixture of the two, often with the addition of manganese dioxide. The color acquired by the steel depends on the temperature of the bath as well as its composition. Other fused oxidizing baths can probably be used also.

(5) *Temper Colors.* The "temper colors" seen on steel when it is tempered between 220 and 320 deg. C. are due to a thin layer of oxide. Such a layer of oxide is often applied as a protecting layer, the blue color being the one usually used. The steel is heated in free

air, and the various colors will be produced at the following temperatures:

	Deg. C.	Deg. F.
Pale yellow	220	418
Straw	230	446
Brown	255	491
Purple	280	536
Pale blue	300	572
Dark blue	315	599

The color depends somewhat on the duration of the heating and to a lesser extent on the nature of the steel.

(6) *Hot Oxidizing Solutions.* Boiling alkaline oxidizing solutions have been used, such as boiling sodium hydroxide solution, containing sodium picrate (Guerini process), sodium nitrate, sodium peroxide, etc. It seems probable that many oxidizing solutions would be found suitable. The nature of the steel affects the structure of the coating produced.

(7) *Miscellaneous.* Other processes for producing black coatings include the following: Immersion in boiling solution of lead acetate and sodium hyposulphite; making the iron the anode in an electrolytic cell, the oxygen from the decomposition of the water giving a coating of oxide; dipping in 10 per cent potassium bichromate solution, followed by heating in a smoky flame; copper plating by dipping in copper sulphate solution, followed by immersion in a solution of sodium hyposulphite and hydrochloric acid. A brown color may be produced by heating in steam with acid vapor for a few hours. A type of coating termed "black nickel" is used rather extensively. This is electrolytically deposited, but the commercial practice varies widely as to the composition of the bath used and hence also the coating. The deposit made from the sulpho-cyanate bath is most uniform in its composition and properties and is to be preferred, particularly if the article has received a preliminary coating of zinc.

b. Salts. In a coating of this type of rather wide commercial application, the iron at the surface is converted into a salt by immersing the steel in hot dilute phosphoric acid, sometimes containing manganese dioxide, soluble chromates, or other metallic salts. After the proper length of immersion, the steel is withdrawn and dried. The color is then grayish-white, but becomes black when oiled. This is called the Parker (57) or the Coslett process (59). Its resistance to corrosion is of the order of the light oxide coatings.

III. Methods of Testing Coatings

1. Description of Methods

Considerable difference of opinion has been expressed concerning the relative merits of the different types of the protective coatings, and various tests have been suggested to show the virtues of a particular coating. The basis on which some comparative tests are made is incorrect; for instance, the comparative values of lead, tin, or terne plate and zinc cannot be determined by treatment with sulphuric acid or ammonium chloride solutions, as is sometimes suggested; the Preece test should not be applied to sherardized coatings, and results obtained by this test on hot-dipped or plated coatings are not comparable. If the Preece test is made on the same type of material, by the same operator, under exactly the same conditions of time, temperature, concentration of solution, etc., comparable results may be obtained. There is no universal test that can be applied to the different kinds of protective coatings; each type must be considered alone and the limitations of each must be taken into account.

The usual methods for testing zinc coatings are the Preece test (24), the hydrochloric acid-antimony chloride method (68), the basic lead acetate method (71), and the salt spray test (69), which recently has been receiving considerable attention. In addition to these purely chemical methods, metallographic measurements are also made of cross-sections of the coating of the material under consideration.

a. Stripping Tests. The Preece test is made by dipping, for a period of one minute each, the carefully cleaned sample in a solution of copper sulphate. The sample is washed in running water and lightly rubbed with clean waste between dips, and the appearance of bright adherent copper indicates the end of the test. The solution is prepared by dissolving 36 parts of commercial copper sulphate crystals in 100 parts of water and then adding some cupric oxide to neutralize any free acid. This solution is diluted with water until its specific gravity is 1.186 at 18 deg. C., and it should be used at approximately the same temperature.

Hydrochloric Acid-Antimony Chloride Method

The hydrochloric acid-antimony chloride method for determining amount of coating on galvanized metal is as follows:

A sufficient number of specimens should be used in each test to have an area of not less than 25 sq.cm. (4 sq.in.). They are weighed (to the nearest milligram) and then dipped in 100 cc. (or more if necessary to cover the specimens) of concentrated hydrochloric acid (specific gravity 1.20), to each 100 cc. of which has been added 5 cc. of a solution made by dissolving 20 g. of antimony trioxide in 1000 cc. of concentrated hydrochloric acid. The same portion of hydrochloric acid may be used repeatedly up to five times, by adding before each immersion an additional 5 cc. of the antimony chloride solution. The samples are immersed in the solution for one minute. They are then washed and scrubbed in running water to remove the deposited antimony, and are dried and reweighed. The loss in weight represents the weight of the zinc coating, which is calculated directly to grams per $dm.^2$; or to ounces per sq.ft. by multiplying the $g/dm.^2$ by 0.328 (or for practical purposes, by dividing by 3). Often it may be most convenient, on irregular shaped parts, to express the weight in grams (or milligrams) per piece, thereby avoiding uncertainty due to the area of a sample.

Basic Lead Acetate Method

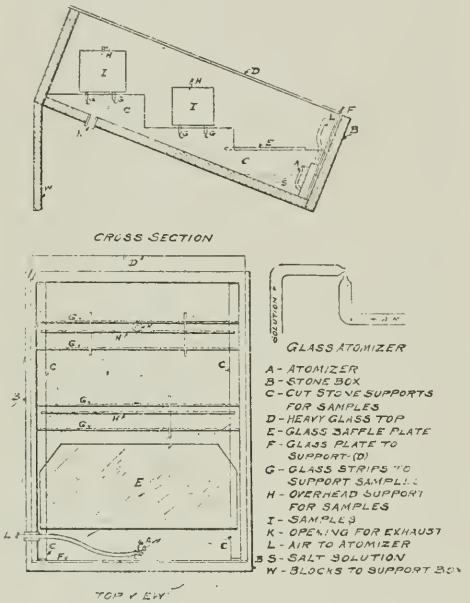
The basic lead acetate method is carried out essentially as follows:

The solution is prepared by dissolving 400 g. of crystallized lead acetate in 1 liter of water, to which is then added 4 g. of powdered litharge. After shaking, the solution is decanted or filtered and is diluted until the specific gravity is 1.275 at 15.5 deg. C. The weighed test specimens are immersed in a sufficient amount of this solution to cover them, and at the end of three minutes are removed and freed from adhering lead by rubbing or brushing lightly. They are again immersed for successive three-minute periods (usually four periods are sufficient) until a bright iron surface is exposed. The specimens are then cleaned, dried and reweighed, the loss in weight representing the weight of the zinc coating.

b. Salt Spray. The operation of the salt spray test has received considerable attention at the Bureau of Standards during the last two years, and although all types of protective coating have been tested, special attention was given to zinc coatings.

The test as conducted at the Bureau of Standards is made in an Alberene stone box, with a glass cover and glass supports for the samples. The construction is indicated in the accompanying diagram. The stone box will run down to the edge instead of dripping on the samples.

A 20 per cent solution (by weight) of commercial sodium chloride (20 g. salt and 80 cc. water, or 2 lb. salt and 1 gal. water), filtered if necessary, is used, and



SALT-SPRAY BOX FOR ACCELERATED CORROSION

with an air pressure of about 6 or 7 lb. per sq.in. a very fine mist is produced.

The compressed air is passed through a glass-wool or cotton plug and then through water to remove oil and dust, and to saturate the air with water vapor, which prevents concentration of the salt solution and crystallization of the salt on the tips of the atomizer. The baffle plate prevents the salt spray from blowing directly against the test pieces.

The samples, after washing with gasoline and ether to remove all grease, are placed in the spray box in a vertical position on the glass rods or strips. They are removed from the bath every twenty-four hours, washed with water, using a moderately stiff bristle brush, and after drying are carefully examined for the presence of red or yellow iron rust. The first appearance of rust indicates the conclusion of the test, but valuable information may be obtained by continuing the test and observing the extent of the corrosion produced by longer exposure.

If Alberene stone is not available, the box may be made of glass, stoneware, porcelain, waterproofed wood or any other insoluble and non-corrosive material, and all connections should be of glass or rubber.

2. Comparative Values of Different Methods

The hydrochloric acid-antimony chloride and basic lead acetate methods are "stripping tests" and give the total amount of coating on a surface; the Preece test has been used to show thin spots and also to show, in a general way, the thickness of the coating. The lead acetate method may also be used to show thin spots, but used in this way is liable to show the same irregularities that led committee A-5 of the A. S. T. M. to condemn the Preece test (75).

The comparative value of the hydrochloric acid-antimony chloride and the basic lead acetate methods for stripping are discussed in the report of committee A-5 for 1917 (75), and either is considered satisfactory for sheet metal and wire, which were the materials tested.

The hydrochloric acid-antimony chloride method has been used at the Bureau of Standards almost entirely for stripping because it removes the coating more quickly and can be applied to material of any shape and to all types of zinc coatings. The basic lead acetate method does not lend itself to irregular pieces such as bolts, nuts, screws, etc., or parts with holes in them, on account of the difficulty of removing the precipitated lead from the small depressions or holes and on account of the possible failure to react with sherardized coatings, which is also characteristic of the Preece test.

The hydrochloric acid-antimony chloride solution usually removes plated zinc completely in from five to fifteen seconds and hot-dipped zinc in less than thirty seconds, but it has often been found that sherardized zinc is not completely removed during a one-minute immersion, four immersions sometimes being required to remove all the coating.

Progressive Loss of Coating

The following results illustrate the progressive loss of coating when four pieces of sherardized sheet metal, 1 in. square, were dipped in the hydrochloric acid-antimony chloride solution for periods of one minute each.

LOSS OF WEIGHT IN GRAMS

	A	B	C	D
First dip	0.3371	0.4102	0.3966	0.8380
Second dip	0.0490	0.0158	0.0171	0.0477
Third dip	0.0017	0.0017	0.0017	0.0040
Fourth dip	0.0010	0.0008	0.0010	0.0007

The fourth value may be attributed to iron, as these figures are of the general magnitude of those obtained when bare iron is treated with the acid mixture used in stripping.

The following figures indicate that the acid method of stripping may be more accurate for electrolytic zinc than the basic lead acetate method which was shown by accurately weighing the amount of zinc deposited on some iron sheets and then stripping them:

Method of Stripping	Weight of Coating in Grams: Deposited	Stripped	Per Cent Coating Found
Lead acetate	0.2888	0.2537	88.0
	0.1694	0.1572	93.0
Hydrochloric acid-antimony chloride	0.2141	0.2157	100.7
	0.1965	0.1992	101.4

The salt spray test has been applied to a large number of samples, some of which were taken from stock at various plants, while other samples were prepared especially for this purpose. These tests were made in conjunction with stripping tests and metallographic examination. A study of the results obtained indicates that there is no close agreement between the life of a coating determined by the salt spray test, the amount of zinc determined by stripping and the thickness of the coating measured metallographically. The following

examples taken from the large number tested illustrate the differences between amount of coating determined by the two methods and the variation shown by the salt spray test.

Sample	Thickness of Coating (Inches) — Microscopic Examination of Cross Sections: Stripping	Average	Average Minimum
A (hot dipped)	0.00276	0.00303	0.00173
	0.00307	0.00646	0.00339
B (hot dipped)	0.00191	0.0028	0.00233
	0.00185	0.0046	0.00268
C (hot dipped)	0.00181	0.0039	0.00260
	0.00172	0.0029	0.00189

Salt Spray Test

Type of Coating	Thickness of Coating (by Stripping)	No. of 24-Hr. Days Required for First Appearance of Rust
Electroplated	0.00040 inch	3
Electroplated	0.00077	15
Electroplated	0.00073	9
Hot dipped	0.00109	5
Hot dipped	0.00133	6

The tests from which the above conclusions were drawn were repeated to see if more consistent results could be obtained, but no better agreement was found. It was thought these differences might be due either to the manipulation of the salt spray test, to the very irregular shapes of the test pieces, or a lack of uniformity in different samples of the same kind from the same lot. It was found on investigation that samples of plated and hot-dipped sheets and chilled-cast zinc placed in the salt spray tank in a vertical position corroded more rapidly than those in a horizontal or an inclined position. It was also found that zinc is not removed by immersion in a solution of salt nearly as rapidly as it is by a spray of the same solution, and consequently zinc in the holes or depressions in the surface of a specimen where the salt solution may collect will not be removed as rapidly as at other places. It becomes evident that although the thickness of plated zinc on recessed parts is less than on outer surfaces they may not show failure as rapidly as the outer surfaces. It was also found that the amount and distribution of zinc on different samples of sheet metal, prepared at the same time and presumably under similar conditions, varied so much that the results obtained on one of several samples could not be taken as characteristic of the set.

To Remove Basic Zinc Carbonate Coat

A hard and adherent coat of basic zinc carbonate nearly always forms on the surface of the test piece when exposed to the action of the salt spray, and efforts to remove this completely without affecting the metallic zinc have not been successful. Treatment with acids undoubtedly removes zinc, although Tambou (74) recommends a mixture of ammonium carbonate, ammonium chloride and ammonia for differentiating between zinc oxide and metallic zinc. This solution was not found satisfactory, as it attacks metallic zinc somewhat readily. A zinc plated sheet (51.7 sq.cm.) immersed for periods of 15 minutes each in a solution lost weight as follows:

First dip	6.4 mg.
Second dip	3.6 mg.
Third dip	4.1 mg.
Fourth dip	4.2 mg.

After trials of various methods to remove the basic zinc carbonate, the one finally adopted is to brush the sample daily in running water with a moderately stiff bristle brush. This was found to have practically no effect on metallic zinc, but it did not remove all the zinc salts. This layer must have some protective action, and as it is not uniformly distributed, zinc will be removed more rapidly at some places than others, producing erratic results.

The salt spray test as a measure of the relative value of zinc coating depends on the time required for the complete removal of the zinc at the thinnest point, which is usually indicated by the appearance of iron rust. It was thought that iron exposed to the action of the salt fog would show rust almost at once, but this is not always true. Numerous cases have been observed, however, in which areas of iron as large as 1 sq.cm. have been completely freed from zinc, as shown metallographically, yet no rust appeared. This is probably due somewhat to the type of iron exposed and also to the protective action of the adjacent zinc through the strong salt solution as electrolyte, for it can readily be shown that certain steels corrode more readily than others and that the "zone of protection" exerted by zinc on iron increases readily with the concentration of the salt solution. It is difficult to explain the quick appearance of iron rust on zinc-coated material in the salt spray test unless it is assumed that there is an insufficient layer of salt solution between the zinc and exposed iron to allow the zinc to exert its electropositive nature or that the basic zinc carbonate which is formed collects in such a way that it insulates the zinc from the iron and destroys its protective effect.

Salt Spray Test Regarded as Best

Although the salt spray test is subject to many objections, it may be regarded as the best test for zinc coatings that has yet been developed. It is especially useful in determining the relative value of zinc coatings for marine exposure. No definite statement can be made about the life of zinc coating in this test, but in a general way, a sample showing rust spots in less than 1 day (24 hours) should be regarded as unsatisfactory, while a life of two or three days would indicate a coating that could safely be used under moderate conditions of exposure, and a life of at least 4 to 6 days should be required for severe conditions of exposure.

Since electro-negative coatings accelerate the corrosion of iron at exposed points, continuity of coating is of more importance than the thickness of the protecting layer. Any test which will effectively show the presence, number and approximate size of breaks or pin-holes may be used to indicate in a general way the quality of the coat as applied. The salt spray test will detect "pin-holes" in a comparatively short time (usually from 3 to 10 hours) and on longer exposure give some indication of the probable life of the protective coating. But the comparative value of the various metals cannot be determined by this method alone; purpose and service conditions also must be taken into consideration.

Other Tests

Other tests which detect lack of continuity in metal coats have the advantage of speed, while their application does not spoil the part tested for subsequent use. Such tests are based upon color reactions which take place between the solution and exposed (uncoated) iron. Pin-holes in most electro-negative coatings can be detected readily by immersing the sample in a 1 per cent solution of sodium ferricyanide in 2 per cent sulphuric acid. The appearance of a blue precipitate at any point indicates a hole in the coating, or exposed

iron. This test is readily applied to the electro-negative coatings such as lead, copper, lead-tin, or lead-antimony alloys. Acetic acid may be substituted for sulphuric acid, but the action will be slower. Similar results may be obtained by exposing to the air a specimen which has been dipped first in dilute acetic acid and then in a warm solution containing 5 per cent hydrogen peroxide. Breaks in the coating are indicated by a blue precipitate.

The oxide coatings cannot be tested by any method so far developed because the iron in the coating gives the same results as the base metal itself, and their protective value depends often on the amount of oil in the coating.

The phosphate coatings are more readily tested, but in this case, too, the iron in the coating makes it difficult to draw definite conclusions. A great many tests have been made at this Bureau on samples prepared by treatment with the various phosphoric acid solutions, and it can be definitely stated that this treatment does not give satisfactory protection for steel parts that are exposed to water, salt air, moist atmosphere, or considerable friction, but it has some merit if conditions of exposure and handling are very moderate. The value of this treatment is increased if the treated surfaces can be frequently oiled, but this will not materially increase its resistance to mechanical action. The experience of this Bureau indicates that this treatment has not been successfully applied to case-hardened products without removing most, if not all, the hardened surface by sand blasting or pickling.

IV. Recommendations Concerning Coatings

1. Zinc coatings should be given preference over all others when the object of the coating is protection against corrosion only.

2. For general use on large smooth surfaces, sheets, rods, wires, pipes, etc., the hot-dipped zinc coatings are entirely satisfactory, though some of the other processes are more economical in the amount of zinc used. On articles which must be sharply bent or otherwise shaped, too heavy coatings of this hot-dipped type should not be used on account of the tendency of the coating to flake off at such points.

3. One oz. of zinc per sq.ft. of surface exposed (0.0017 in. thickness) may be considered as satisfactory for most purposes, but less may be sufficient if evenly distributed.

4. Of the different types of zinc coatings the "hot-dipped" and sherardized are not to be recommended for hardened and tempered steels (springs, etc.); the plated zinc and the sherardized coatings are both recommended for accurately machined parts; threaded portions, however, are best coated by sherardizing; the "spray" coatings are valuable for large or complex parts which must be coated *in situ* or after assembling.

5. For indoor use and to a limited extent outdoors, for parts which are so placed as to be easily inspected and which are kept well oiled, other coatings than zinc, e.g., the oxide and other black finishes, may be used. For *severe* service, zinc only should be depended upon.

6. In general, nothing is gained, from the standpoint of resistance to corrosion, by first coating an article with copper, or a similar metal, and then finishing with zinc. If a zinc coating is to have a black finish, "black nickel" may be used as a finish.

7. The use of oil and like substances on any type of coating is to be strongly recommended. The life of zinc coatings, particularly those of a porous character, may be prolonged almost indefinitely by periodically oiling them.

8. The time required for the appearance of rust on zinc coated articles when exposed to salt spray may in a general way be taken as an indication of whether the coating is satisfactory for outdoor exposure, e.g.:

24 hours ..... unsatisfactory
48 to 72 hours.....for mild exposure
96 to 144 hours.....for severe exposure

Potash From Wood Ashes

An investigation concerning the production of potash from wood ashes, conducted by the U. S. Forest Products Laboratory at Madison, Wis., disclosed the following facts:

The ash content of hardwoods ranges from 0.5 per cent to 3.02 per cent, with an average of 0.61 per cent. The ash content of the coniferæ seems to vary from 0.02 to 0.82 per cent, with an average of 0.30 per cent. There may, however, be very wide variations in the ash content of the same species, as is instanced by black walnut with a minimum ash content of 0.21 per cent, a maximum of 1.96 per cent, and an average of 0.79 per cent; or chestnut oak, whose minimum, maximum and average ash contents are respectively 0.33 per cent, 1.96 per cent and 0.77 per cent.

The potash content of pure, well-burnt ashes may be very high, ranging from 10 per cent up to 35 per cent. These figures are, however, of but little commercial value, since all commercial ashes contain impurities, such as sand, sawdust or charcoal, and these impurities may make up a very large per cent of the total ash. The potash content of commercial wood ashes may vary over a comparatively wide range, depending somewhat on the wood and the kind of furnace or stove used. The average of 111 analyses made in Connecticut from 1906 to 1915 was 3.6 per cent K_2O.

The initial cost of a potash plant of 24 leachers, including building, is between $3000 and $4000. The cost of manufacture of potash, not including the cost of the wood ashes, will vary from about 7 to 17c. a lb., depending upon the kind of ashes obtained and whether or not the plant is running at full capacity.

It is evident, therefore, that the manufacture of potash from wood ashes will not be a paying proposition when normal prices are resumed, except in those cases where the plant has already been paid for and is owned by the potash maker who makes no charge for his own labor but accepts his profit as compensation for his work. Under these conditions the cost of manufacture of potash, exclusive of the cost of ashes, may be reduced to about 5c. a pound.

War Department Disposes of Lead

Disposition of the surplus stocks of lead owned by the War Department is being made at current local market prices in the community in which the surplus is held. This surplus is scattered throughout the country, and in no one place is there a large quantity. Reports from the various bureaus show a total amount of 7000 tons of lead to be in possession of the War Department. This surplus of 7000 tons represents but a small percentage of the year's production of lead and is not sufficient in quantity to affect the market in any way. This lead is not sold in quantity at one time but in small quantities in various places.

Treatment of Cuprodescloizite for Extraction and Recovery of Vanadium, Lead and Copper

Preliminary Experiments to Determine Best Method of Preparation and Extraction of Vanadium From the Ore—Niter Cake-Sulphuric Acid Extraction Most Economical—Leaching Tables—Copper and Lead Recovered Sufficient to Pay Costs

By J. E. CONLEY*

OWING to the strong competition of the Peruvian patronite as a source of vanadium, the production of this metal from ores found in the United States has in a measure been neglected. The rumored decrease in the available supply from Peru, and the continued demand for vanadium in the steel industry, are sufficient grounds to encourage and stimulate the production of this important metal in this country.

Some vanadium is being obtained by the treatment of roscoelite and also as a by-product in the treatment of carnotite ores for radium. The treatment of ores for vanadium alone has not been extensively done and certainly warrants the attention of companies and individuals owning vanadium properties, as well as of the consumers themselves.

A lead-copper-vanadium mineral, evidently cuprodescloizite, has presented itself as a possible source of vanadium worthy of consideration. For this reason, an investigation into the metallurgy of the vanadium especially applied to this mineral was deemed justifiable.

A sample of this cuprodescloizite was obtained by the Bureau of Mines through the courtesy of Mr. L. C. Shattuck and Mr. Houle of the Shattuck-Arizona Copper Co. of Bisbee, Ariz., and to whom we are indebted for their kindness.

Difficult to Mine

It is claimed by those who have examined the mine that a considerable amount of this mineral is available but likely to present some difficulty in mining, owing to the nature of the deposit. The mineral is found in a large vug, or cavity, as a deposit on a brecciated quartz.

The quantity of ore in this deposit, although not available at present owing to the caved-in condition of the mine, is best indicated by an extract from a letter recently received from the Shattuck-Arizona Copper Co. and is as follows: "At one time in 1915, the vanadium-bearing ore was exposed on the 600 level for a length of 200 feet, average width 3 feet and total height 600 feet. In this block was estimated a tonnage approximately 3000 tons of ore averaging 10 per cent V_2O_5 (vanadium pentoxide)"; and "In addition to the so-called high-grade ores a large tonnage of ore assaying from 1 to 1½ per cent V_2O_5 is exposed."

The Mineral Described

The sample submitted to the Bureau of Mines consisted of a large sample weighing nearly 40 lb., and composed largely of the mineral deposited on hard quartzite fragments so as to form a cementing material. The mineral itself is admirably described by Mr. R. C. Wells[1], who examined a specimen several years ago and describes it as follows:

"The mineral occurs in the form of stalactites. The smaller aggregates radiate from a narrow base and end in round clusters ⅛ mm. in diameter. The larger growths occur in reniform masses several centimeters in diameter. The latter are coated with a red powder, but the smaller aggregates have an olive hue. The fractured surface of all varieties possesses a dark-brown luster and shows a radiating structure. The streak is a dark olive buff."

There is this difference, however, that the red powder, evidently vanadium pentoxide, occurs as a thin layer between the quartzite and the deposit of mineral itself, rather than being found as a coating on the mineral. The fractured surface also has more of a bluish-gray metallic luster than a dark-brown color.

Preparation of the Sample

The sample described was taken and ground to 20 mesh, and gave on analysis the following:

Insol	52.50 per cent
V_2O_5	8.06 per cent
CuO	7.31 per cent
PbO	23.02 per cent
Fe	2.36 per cent

From the above analysis it is seen that the ore would also be valuable as a lead and copper ore if found in any quantity. The iron was evidently introduced by the grinding, since scarcely more than a trace is present in the original sample. This was to be expected, owing to the extreme hardness of the quartzite and to the difficulty encountered in grinding it. The phosphorus and arsenic in the sample were not determined, but were shown to be present by qualitative tests. A screen test made on the sample gave the following figures:

Mesh	Per Cent
Through 20 on 40	17.38
Through 40 on 60	19.13
Through 60 on 80	8.48
Through 80 on 100	8.86
Through 100 on 120	3.53
Through 120 on 150	1.63
Through 150 on 200	6.23
Through 200	34.76
Total	100.00

Very little attempt was made to improve the grade of the ore by concentrating. Some attention, however, was given to the possibility of affecting some concentration by careful screening. From the nature of the ore it was thought that this scheme might possibly be applied.

The mineral is softer than the quartz and would consequently be expected to grind more readily and,

*Published by permission of the Director of the U. S. Bureau of Mines.

[1] *Amer. Jour. of Science*, 4, 36. 636-638. 1913.

therefore, could be separated from the quartz by proper screening. A test was made on a ground sample to determine the possibilities of this procedure. The results obtained are given below:

Mesh of Product	V_2O_5 Per Cent	Copper, Per Cent	Lead, Per Cent
Retained on 20	7.48	5.05	18.17
Passed through 20	8.06	5.95	21.37
Passed through 150	8.58	....	....

It is seen that the fine product passing the 150-mesh sieve is only of a slightly better grade than that of the material retained on the 20-mesh. From these results it would seem that the slight improvement in the grade of the ore is scarcely sufficient to justify the treatment.

As confirmatory of the above results, it was noticed that in preparing a sample of the 20-mesh material for analysis by grinding in an agate mortar and frequently screening off the fine ore a considerable portion of the mineral persisted with the quartz until practically all of the sample had been ground. From these facts it seems that concentration by screening could not be recommended.

Other methods of concentration were not tried for several reasons. First, the ore, since it contained 8 per cent of vanadium pentoxide, was already fairly high; and, second, since the gangue is a hard quartz, the grinding costs would be necessarily high, and therefore to be avoided. The coarse material would also facilitate filtering and be desirable to the final recovery of the lead in the subsequent sliming process. Some difficulty would also be encountered in slime losses, since the red powder of V_2O_5 would tend to be carried off as slime and would necessitate special treatment.

The mineral itself, neglecting the powder, could be easily concentrated as would no doubt be necessary on the low-grade material. The cuprodescloizite is fairly heavy, while the quartz is a light mineral. A rough test made by passing a small quantity of the ground sample over the Wilfley table confirmed the above assumptions and gave excellent promise of a good concentration and clean separation.

Methods Tried for Extraction of Vanadium

The object of experiments on this ore was to determine the best procedure for extraction of the vanadium and then to work out a method for recovery of the lead and copper if possible. Methods that were found ill-suited for a good extraction of the vanadium were given but little consideration. The schemes tried, with a brief statement of the results obtained by each, are given as follows:

1. *Leaching With Hydrochloric Acid:* Experiments were made with hot and cold dilute and concentrated hydrochloric acid. It was found that if used in large excess this acid decomposed the ore fairly well, but the vanadium was deposited on the insoluble residue as the oxide before the solution could be filtered. An extraction of about 70 per cent was obtained with the amount of acid commercially feasible.

2. *Leaching With Sulphuric Acid:* Experiments were made with dilute and concentrated sulphuric acid in the hot and the cold. The results finally obtained were found to be quite satisfactory, and are given later in this report.

3. *Treatment With Concentrated Sulphuric Acid Under Pressure:* These tests were made by mixing the ore with sufficient acid to make a thick paste and then heating in a capped iron tube for from 2 to 3 hours at 400 deg. C. Some of the experiments showed only a 15 per cent extraction, the best obtained being around 70 per cent. In one or two of the earlier tests which were made in a thick-walled hard glass tube, which burst before reaching 400 deg. C., an extraction as high as 85 per cent was obtained, a fact which proves that the high temperature and pressure are undesirable.

4. *Fusion With Niter Cake:* The preliminary tests were made with c.p. sodium bisulphate, which was later replaced by the commercial salt commonly known as niter cake. As a whole, the fusions with niter cake alone were found unsatisfactory, in that even by using as much as three and four times as much cake as ore, the extractions could not be raised above 85 per cent. It was found, however, since approximately two-thirds of the ore could be decomposed by heating it with an equal weight of the niter cake, that this fusion could be satisfactorily used as a preliminary treatment, followed by a sulphuric acid leach.

5. *Fusions With Soda Ash, Soda Ash and Caustic Soda, and With Soda Ash and Salt:* Fusions were made with the above mentioned fluxes to obtain a vanadium soluble slag. Carbon was added as a reducing agent to obtain the lead as a button. It was found that the amount of fluxes required to obtain a sufficiently fluid slag was very large, and the amount of vanadium extracted by leaching the slag with water was only from 65 to 70 per cent.

A straight alkaline leach was not tried on the ore, since the slag obtained in the above fusions after being pulverized and heated for some time gave practically the same conditions.

6. *Volatilization of the Vanadium as the Oxytrichloride With Chlorine and as the Tetrachloride With Hydrochloric Acid Gas:* From the theoretical standpoint, this method is the most ideal of all the methods tried. The vanadium would be recovered as a high-grade oxide, and the lead and copper in the tails rendered soluble in hot water. The treatment requiring chlorine would eliminate the arsenic, since the ore would have to be reduced with either carbon or hydrogen at a red heat, which would, no doubt, volatilize the arsenic. The hydrochloric acid gas treatment was found applicable on the original ore, but the arsenic was carried over with the tetrachloride. Both of these methods gave promising results on small samples of one to two grams, but when tried on larger samples gave very poor recoveries.

7. *Chloridizing Roasts With NaCl and With NaCl and Sulphur:* A few chloridizing roasts were made in an attempt to render the vanadium soluble. The amount of vanadium rendered soluble by this treatment was only a small percentage of the total. The preliminary tests gave such poor promise of success that this method of attack was given but slight consideration.

8. *Combination of Niter Cake-Sulphuric Acid Treatment:* This treatment is the one that was finally considered to be the most economical and, in general, the most satisfactory. Details and results are given more fully in other parts of this report.

Since the niter-cake fusion is given as a preliminary treatment of the ore, it was thought advisable to give a few of the results obtained in the tests. A considerable number of experiments were made to fix the conditions best suited for a maximum vanadium

extraction. The preliminary fusions were made with the fused c.p. bisulphate which was later replaced by niter cake. The results obtained are given in Table I.

TABLE I.

No. of Test	Weight of Ore	Weight of $Na_2S_2O_7$	Ratio Ore to Flux	Extraction V_2O_5, Per Cent	Remarks
1	10 g.	5 g.	2 : 1	11.3	Practically all of SO_3 driven off by blast.
2	10 g.	5 g.	2 : 1	38 0	Part of SO_3 driven off.
3	10 g.	5 g.	2 : 1	44.4	Heated only to fusion.
4	10 g.	8 g.	10 : 8	65.7	Heated only to fusion.
5	10 g.	10 g.	1 : 1	85.7	Heated only to fusion.
6	10 g.	12 g.	5 : 6	83.5	Heated only to fusion.
7	5 g.	7 5 g.	2 : 3	85.7	Heated only to fusion.
8	5 g.	10 g.	1 : 2	87.2	Heated only to fusion.

Another series of tests very similar to those given in Table I were made with niter cake, and the results obtained are given in Table II.

TABLE II.

No. of Test	Weight of Ore	Weight of Flux	Ratio Ore to Flux	Extraction V_2O_5, Per Cent	Remarks
1	5 g.	5 g.	1 : 1	44.1	Scarcely all of niter cake fused.
2	5 g.	5 g.	1 : 1	66.2	Heated only to fusion.
3	5 g.	5 g.	1 : 1	48.4	A little SO_3 driven off.
4	5 g.	5 g.	1 : 1	29.1	SO_3 driven off by blast.
5	5 g.	6 g.	5 : 6	70.6	Barely fused.
6	5 g.	7 g.	5 : 8	80.3	Barely fused.
7	5 g.	10 g.	1 : 2	85.1	Barely fused.

The results, in general, show that the extractions are a little lower in the niter-cake fusion than in the bisulphate fusion, a fact which is no doubt explained by the presence of free nitric acid in the niter cake. This effect could in a measure be offset by adding a small quantity of a suitable reducing agent.

From these results, it is seen that the best extraction is obtained when the mixture is heated only sufficiently long to melt all of the niter cake. On larger samples in which the heat is applied more slowly the fusion becomes almost a sulphatizing roast, since very little fusion takes place. On the small samples a distinct fusion is obtained when the heat is applied more rapidly. In general, the extraction is a little better on small samples than on the larger, but as is shown in Table V about two-thirds of the vanadium is consistently extracted with a ratio of 1:1. The extraction is poor if the heating is prolonged, even if the amount of flux is increased, as is shown in Table III.

TABLE III.

No. of Test	Weight of Ore	Weight of Niter Cake	Extraction V_2O_5, Per Cent	Remarks
1	25.0 g.	25.0 g.	56.0	Samples heated longer than advisable
2	25.0 g.	30.0 g.	61.1	Samples heated longer than advisable.
3	25.0 g.	35.0 g.	62.1	Samples heated longer than advisable.
4	25.0 g.	40.0 g.	54.3	Samples heated longer than advisable.
5	25.0 g.	45.0 g.	50.8	Samples heated longer than advisable.
6	25.0 g.	50.0 g.	54.3	Samples heated longer than advisable.

In order to determine the amount of acid that would be required to react with all of the bases, an analysis of the ore was made. The amount of acid thus required from a theoretical standpoint was calculated and found to be approximately equal to 30 per cent of the weight of the ore. Several series of tests were made using this amount of acid, which was gradually increased up to the amount necessary for a good extraction.

A considerable number of tests were made, varying the amount of acid and the time and temperature of heating. The results obtained are given in Table IV. As the quantity of acid used was insufficient to cover all of the sample, enough water was first added to moisten the ore. The acid was carefully added from a burette and the samples heated as indicated at a temperature of 175 to 180 deg. C.

TABLE IV

No. of Test	Weight of Ore	Cc. Acid H_2SO_4	Weight of Acid	Per Cent Excess Over Theoretical	Time Heated, Minutes	Extraction, Per Cent
1	10 g.	1.6	2.94	None	15–15	57.2
2	10 g.	1.8	3 31	12 5	15–15	61.1
3	10 g.	2.0	3 68	25 0	15–15	69.0
4	25 g.	4 0	7.36	None	60–15	60.4
5	20 g.	4 8	8 83	50 0	90–15	77.7
6	25 g.	6 0	11.04	50 0	60–15	82.3
7	25 g.	8 0	14 72	100.0	15–15	85 1
8	25 g.	8 0	14 72	100.0	30–15	90.1
9	25 g.	8 0	14 72	100.0	45–15	95.7
10	25 g.	10 0	18 40	150.0	15–15	93.5
11	25 g.	10 0	18.40	150 0	30–15	95.9
12	50 g.	20 0	36 80	150 0	45–15	94 4

The table shows that a 95 per cent extraction can be obtained with an amount of acid equal to twice the theoretical quantity. This fact was confirmed by a number of other tests. The first figure under the heading "Time Heated" refers to the actual time the samples were heated with acid alone and the second figure indicates the time of heating after diluting with 60 to 75 cc. of water.

Some trouble was encountered in the earlier experiments owing to the tendency of the vanadium to separate from the solution before the filtering could be accomplished. An attempt was made to eliminate this trouble by passing a slow stream of sulphur dioxide through the solution during the treatment. This procedure was found to prevent the precipitation of the vanadium and to increase the extraction a small amount, but it was later found to be wholly unnecessary, in that the same object could be attained by adding only sufficient water to permit filtering and washing. From these results it would be possible to obtain an extraction of 95 per cent by using 1172 lb. of 66 deg. B. sulphuric acid per ton of ore.

Treatment by Combination of Niter-Cake Fusion and Sulphuric Acid Leach

This treatment consists of subjecting the ore to a preliminary fusion with niter cake followed by a hot-water leach, then treating the residue with sulphuric acid. As previously stated, it was found that by heating the ore with an equal weight of niter cake approximately two-thirds of the ore could be decomposed and

TABLE V.

Niter-Cake Fusion Treatment								H_2SO_4 Leach of First Residue					Results		
				Extraction						Extraction			Combined Extraction		
No. of Run	Weight of Ore, Grams	Weight of Niter Cake	Weight of Residue	Per Cent V_2O_5	Per Cent Cu	Per Cent Pb	Residue, Per Cent Pb	Cc. Acid	Weight of Acid, Grams	Weight of First Residue	Per Cent V_2O_5	Per Cent Cu	Per Cent Pb	Per Cent V_2O_5	Per Cent Cu	Per Cent Pb
1	48	48	42.5	70.20	74.50	58.3	24.49	6.8	12.62	41.5	22.60	24.40	25.5	92.80	98.9	83.8
2	100	100	89.8	62.75	65.78	66.3	24.56	a. 3.70	6.82	20.0	34.40	33.15		97.15	98.9	
								b. 3.08	5.66	20.0	28.60	28.50		91.35	94.3	
								c. 2.47	4.55	20.0	28.12	26.70		90.37	92.5	
								d. 1.85	3.42	20.0	19.36	23.41		82.11	89.2	
3	100	100	89.7	59.70	63.1	59.9	23.40	a. 3.70	6.82	20.0	30.90	32.50		90.60	95.60	89.0
								b. 3.08	5.66	20.0	27.15	30.20		86.85	91.50	
								c. 2.47	4.55	20.0	26.70	23.85		85.40	86.95	
								d. 1.85	3.42	20.0	25.20	22.70		84.90	85.80	82.5

the corresponding values extracted. The remaining values are then extracted by leaching the residue with about one-half as much acid as is required in the straight acid treatment. This procedure substitutes an amount of niter cake worth about two-thirds the value of the acid that would be required. This method would entail a slightly increased cost for labor and equipment, but the utilization of the cheaper chemicals would no doubt still render the use permissible from the standpoint of economy.

Experiments With Niter-Cake Treatment

The initial treatment with niter cake should be made under conditions approximately the same as those found to be the most desirable under the experiments on that fusion. The ore should be mixed with the pulverized niter cake and heated barely to fusion. Sufficient water to break up the ore and to permit washing should be used, and boiling should not be continued any longer than necessary to accomplish this. In the experiments to determine the minimum amount of acid to treat the residue from the fusion, the residue was dried and divided into portions for the tests. In the working process the drying would be unnecessary, since the acid could be added directly to the moist residue. A fairly good idea of the results obtained by this method can be had by reference to Table V.

The percentage of the lead remaining in the residues as sulphate was not determined in all cases, owing to the difficulty of recovering the residues quantitatively. In practically all instances where analyses were made, more particularly on the smaller tests on which the residues could be better collected, the percentages of lead as sulphate ran a trifle lower than the vanadium extracted, so that a close approximation can be made in this manner. It was originally planned to allow the lead to remain in the residue, and to concentrate it by sliming, as is being successfully done with radium-barium sulphate in radium extraction, so that the lead would be obtained either as a high-grade lead residue or as a crude lead sulphate.

Result of Actual Sliming Test to Determine Recovery of Lead Sulphate From Residues

An actual sliming test was made to determine the possibilities of recovering the lead sulphate from the residues. A typical sample of the residue obtained by treating a quantity of the ore with concentrated sulphuric acid was placed in a large beaker and water added. The mixture was then violently stirred in order to put the lead sulphate in suspension and then decanted. This procedure was repeated several times and the slimes allowed to settle and were recovered as concentrates. The test gave the following results:

	Grams
Weight of ore used	400.00
Weight of residue obtained	330.00
Weight used for sliming test	300.00
Weight recovered as slimes	165.00
Weight recovered as tails	132.00
Percentage lead in original ore	21.67
Percentage lead in residue	25.08
Equal to 28.89 per cent $PbSO_4$	
Percentage lead in slimes	43.09
Equal to 49.76 per cent $PbSO_4$	
Percentage lead in tails	3.52
Equal to 4.06 per cent $PbSO_4$	
Percentage lead recovered	94.70

The test required considerable water to obtain a good recovery, but this would not be a serious objection commercially, since the same water could be used repeatedly. It would also be desirable in that it would remove the last traces of vanadium not previously washed out, which could be allowed to accumulate in solution until present in sufficient amount to recover.

The values given in Table V for lead extracted were determined by dissolving the lead from the residues with ammonium acetate, so that the figures really represent the lead present as the sulphate. It was assumed that the lead converted to the sulphate could be considered as extracted, since it would be subject to recovery in the subsequent sliming process.

Recovery of the Vanadium From the Solutions as Iron Vanadate

The vanadium recovered by this treatment would be in the form of iron vanadate containing as a minimum about 35 per cent V_2O_5. In the experiments made, a product of variable V_2O_5 content was obtained according to the care used in neutralizing the acid solution and time of boiling. The iron necessary for the precipitation was introduced by adding scrap-iron, which simultaneously replaced the copper. The vanadium was then thrown out from the solution by carefully adding a strong solution of caustic soda until the solution gave but a very slight acid reaction, and then boiling for two to three hours. By this procedure some samples of iron vanadate containing as much as 50 per cent V_2O_5 were obtained with scarcely any of the vanadium passing through into the filtrate as indicated by qualitative tests with hydrogen peroxide.

The copper thrown out of solution by the iron was at first in the form of bright flakes which gradually darkened as the replacement continued. This copper when filtered off and dried was almost black, due no doubt to the impurities from the iron and arsenic from the ore. The cement copper on analysis gave a copper content of 92 per cent, which would easily be converted to the pure metal in the reverberatory furnace.

Some difficulty was encountered with the copper, which must be thoroughly removed from the solution to prevent its being carried down in the iron vanadate. It was found, however, that by permitting the scrap-iron to remain in the solution for a number of hours practically all of the copper could be thrown out of the solution and the iron vanadate then obtained would be nearly free from copper. This procedure allowed a considerable excess of the iron to go into the solution, a fact which did not materially affect the grade of the precipitate, and is objectionable only from a standpoint of economy of iron. As previously stated, the real important factor in controlling the grade of the iron vanadate is the care used in the neutralization with caustic soda.

The neutralization also consumed a considerable quantity of caustic soda, which would be expected, by the necessity of using so large an excess of acid to obtain a satisfactory extraction. This could in a measure be overcome by boiling off a portion of the free acid, and also suggests the possibility of recovering some of the acid.

As an example of the products obtained, by varying the amount of alkali used in the neutralization the following figures are given:

No. of Test	Alkali Added Cc.	Grade of Ppt. Obtained, Per Cent V_2O_5
1	24.99	50.52
2	30.30	48.55
3	32.90	30.37

(1 cc. alkali = 0.08644 grams NaOH)

In these tests three aliquots of 50 cc. each of a solution containing 0.0142 g. of V_2O_5 were taken. The procedure in these experiments was as follows: One-fourth, one-half and three-fourths respectively of the acidity of the solution was neutralized before adding the iron strips to replace the copper. After the copper was filtered off, the remainder of the alkali was added, and the solutions boiled for two and one-half hours. There is little difference between numbers 1 and 2, but evidently too much alkali was added to number 3.

Two Processes of Neutralization

Two procedures were tried in the neutralization: (1) To neutralize a portion of the free acid before adding the iron strips for the purpose of lowering the iron consumption, and (2) adding the iron directly to the acid solution and neutralizing after the removal of the copper. So far as affecting the grade and recovery of the vanadium, there is really very little preference, but (1) is probably more desirable for the saving in iron. A satisfactory iron vanadate is obtained by both methods.

ESTIMATE ON VALUE OF ORE AND COST OF TREATMENT

Value of ore:		
21.37 per cent lead	427.4 lb. at $0.07 per lb.	$29.90 per ton
5.95 per cent copper	119.0 lb. at .25 per lb.	29.75 per ton
8.06 per cent V_2O_5	161.2 lb. at .75 per lb.	120.90 per ton
Total value		$160.55 per ton
Costs for Treatment by Sulphuric Acid Leach per Ton of Ore:		
1172 lb. of acid at $30.00 per ton		$17.50
485 lb. of caustic soda at $0.04 per lb.		18.40
150 lb. of scrap-iron at $0.01½ per lb.		2.25
Expense for mining, grinding, labor for treatment, depreciation, etc.		15.00
Total		$52.15
Costs for Treatment by Sulphuric Acid Niter Cake Method:		
2000 lb. niter cake at $5 per ton		$9.00
600 lb. acid		5.00
Caustic soda required		18.40
150 lb. scrap-iron at $0.01½ per lb.		2.25
Mining, milling, etc.		15.00
Total		$49.65

The costs of mining, milling and labor and materials for treatment, depreciation, etc., are variable factors, depending upon the capacity and location of the plant; but it would seem that under the most adverse conditions the cost should not be greater than $15 per ton of ore.

By reference to the value of the lead and copper present in the original ore, and from the extractions and recoveries considered possible, it would seem justifiable to claim that the return from these, recovered as by-products, would more than pay for the whole treatment of this ore.

Looking at the process from the standpoint of recovering the vanadium only, and assuming a 90 per cent recovery, the value of the product would be:

90 per cent of 161.2 lb., or 144.08 lb., of V_2O_5	$108.80
Cost of treatment by acid alone	52.15
Cost of treatment by niter-cake acid	49.65

It is evident that this ore would permit an expensive treatment, but, of course, would not warrant it simply for that reason. Even if the costs of treatment, which have been given above, were to be doubled, which would be very unlikely, the methods could still be applied to an ore of this value.

Summary

1. The recovery of the vanadium in cuprodescloizite by volatilization in a stream of chlorine or hydrochloric acid gas presents some interesting possibilities, but results obtained were unsatisfactory.

2. The vanadium in this mineral responds more readily to acids than to alkalies.

3. The straight sulphuric-acid leach gives quite satisfactory extractions and permits a good recovery.

4. The niter-cake fusion is undesirable alone but applicable as a preliminary treatment in a combined niter-cake-sulphuric acid process.

5. Copper or other metals undesirable in the iron vanadate must be removed to prevent contamination of the iron vanadate.

6. Boiling of precipitate after neutralization of acid solution is essential to obtain a good grade of iron vanadate.

7. A good grade of iron vanadate can be secured even in the presence of a large excess of iron if the neutralization is carefully controlled.

8. An ore, or concentrate, of the composition of the sample used can be economically treated and possibly at a cost less than the value of the by-products.

I wish to thank Dr. R. B. Moore, under whose direction this work was done, and Dr. S. C. Lind, for many helpful suggestions.

The Edgewood Arsenal

The enlisted men at Edgewood Arsenal, Edgewood, Md., published during the war *Chemical Warfare*. Vol. 1, No. 5, for March, 1919, is a souvenir edition containing the story of Edgewood in text and illustrations. Complete data are given on the production of toxic materials and the filling of shells, grenades, Livens drums and drop bombs. The book contains a wealth of photographs showing the interior equipment of plants, and a complete set of photographs of officers in charge. The book is a credit to the editor in chief and his associates and a fitting tribute to one of the most important branches of the service.

The Oxidation of Ammonia*

Review of the Early Investigations Beginning in 1839 With Kuhlman—Ostwald Process and Apparatus —Improvements Made in Catalyst Screens, Platinum Activation to Foreign Gases Such as Acetylene and Phosphine—Cyanamide Process at Muscle Shoals

By W. S. LANDIS

JUST when ammonia was first intentionally converted into nitric acid or nitrate products I have been unable to learn. Soil bacteria have been doing it for ages. Since the invention of gunpowder, with its increased demand for nitrates, man has endeavored, in places, to assist such bacterial action and thereby lighten his task of recovery. The direct oxidation of ammonia by air through chemical or electrical action seems to have been a scientific curiosity more than a hundred years ago. Eighty years ago Kuhlman, a German technical chemist, after describing at length some very interesting experiments of his own, concluded with the significant remark, "While under present conditions the transformation of ammonia into nitric acid with the assistance of platinum and air has no great value, yet the time will come when it may be of commercial importance."

This commercial prophecy, presented so many years ago, has been a long time reaching fulfillment. Ten years after its utterance, when Chilean nitrate was reaching Hamburg in quantity and prices of nitrate began to decline, its fulfillment must have looked hopeless, as well as during the long years when ammonia prices and nitrate prices were strictly competitive and there was no margin of difference to pay for the transformation. Nevertheless, in the eighty years intervening since the Kuhlman publication, and in spite of the Chilean developments, the Norwegian synthetic nitrate production and the difficult commercial situation, the problem has been attacked in a fairly energetic and persistent manner.

Two Small European Plants

At the outbreak of the European war there were two small plants in Europe capable of transforming ammonia into nitric acid, neither of which, however, had shown sufficient commercial possibilities in the five or six years of operation to warrant further expansion. One of the plants was in Germany, but not operating with any regularity, and never had any production capacity to speak of. Not even the military situation had awakened more than a passing interest in the subject in that country. The long-anticipated war was to be short. There were at hand enormous stores of munitions that had been accumulating for a dozen years. The country maintained supplies of over half a million tons of Chilean nitrate at all times, and peace was sure to be dictated within forty or fifty days after the declaration of war. Why should the oxidation of ammonia be of pressing importance?

But to return to our history of development, Kuhlman in 1839 passed a mixture of air and ammonia through a glass tube containing spongy platinum. At ordinary temperatures no action was observed, but when heated to 300 deg. C. the platinum glowed and with a considerable excess of air in the gas mixture, vapors of nitric and nitrous acids were evolved. At higher temperatures nitrous acid in fairly pure form was obtained. With excess of ammonia the corresponding salts were formed. No quantitative data of any sort were included in the report.

Early Discoveries

Eighteen years later the work was taken up by Schonbein, who found that if spongy platinum was saturated with aqua-ammonia and introduced into air, or preferably oxygen gas, slow oxidation to ammonium nitrate took place at ordinary temperatures. Dense platinum caused this oxidation only at higher temperatures. Finely divided nickel and copper also brought about a similar oxidation of ammonia.

Schonbein was probably the first to use dense platinum in the form of wire. He heated a platinum spiral to just below redness and inserted it into a flask which had been rinsed out with a strong ammonia solution. The gas in the flask turned iodide-starch solution blue and the flask filled with a white fog. Powdered copper reacted in the same way.

Passing over the next few years briefly: Tessie du Motay in 1871 obtained nitrates by passing a mixture of air and ammonia over lead manganate, permanganate or bichromate, heated to 350-400 deg. C. Liebig obtained a similar nitrate by using iron oxide. Wëith in 1874 mixed ammonia gas with ozone and hydrogen peroxide for direct oxidation. Twenty years later Siemens & Halske took out a patent on the use of ozone for this purpose. In 1912 Jones and his co-workers of the Semet-Solvay, following somewhat the outline of du Motay, developed the oxidation by the use of alkaline earth plumbates. Nothing commercial has come to date from any of the above schemes and a great many others along the same lines not enumerated here.

One more name of importance in this early work is that of Warren, who about 1890 passed an ammonia-oxygen or air mixture over platinized asbestos and obtained ammonium nitrate. Although nothing commercial came directly of his work, its publication undoubtedly assisted in causing the cancellation in the German patent office of the celebrated Ostwald patents, which process I shall refer to next.

The Ostwald Process

Twenty-five years ago Wilhelm Ostwald undertook a study of the oxidation of ammonia. He paid much attention to the work of Kuhlman and determined to study the reaction from the scientific standpoint, as nothing along those lines had been done in the fifty years elapsing since Kuhlman's original publication. In his usual careful manner he studied the fundamentals underlying the reaction, and the reading of his exhaust-

*Paper read at the meeting of the American Electrochemical Society in New York, April 3-5, 1919.

ive reports on his investigations would have been of great assistance to many of the recent workers in this field.

Ostwald in general showed the futility of attempting to use spongy platinum as catalytic material, also the necessity of quickly removing the products of the oxidation out of contact with the catalyst. He showed that platinum black was the poorest sort of a catalyzer, yet in spite of this finding, several recent investigators have unsuccessfully attempted to prove otherwise. He noted the activation of dense platinum through operation under special conditions, and particularly the advantage of using such form of catalyst over other types. He further determined the most suitable mixture of air and ammonia for efficient oxidation, and of the utmost importance, that for such mixture a supply of heat above that directly generated by the reaction was necessary for continuous operation.

Ostwald's Apparatus

The result of this work of Ostwald was the building of two oxidation plants of small capacity, the first of which went into operation in 1908. The early apparatus installed underwent several modifications, one of the later type being shown here (Fig. 1).

The exterior tube is of "heat"-resisting and insulating material, and the interior tube of nickel. The

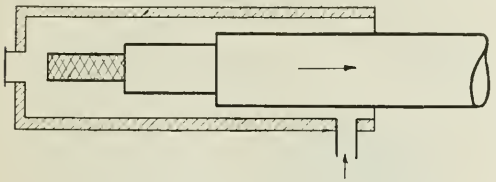


FIG. 1. LATER TYPE OF OSTWALD'S APPARATUS

catalyzer is built up of narrow strips of platinum foil, alternately crimped and flat, thereby producing a series of short tubes. The ammonia gas-air mixture, in the proportions of approximately 10 per cent ammonia, enters the exterior tube at the right, passes to the left in the annular space and out through the red hot catalyzer and nickel tube. This tube is made in sections to enable cheap replacement, as the sections wear unequally. The hot products of combustion lose their contained heat through the nickel tube to the oncoming raw mixture and so serve to keep the apparatus in operation. The apparatus is started by the use of a gas jet at the catalyzer end, or by burning hydrogen gas around the nickel tube. The catalyzer runs very hot, around 800 deg. C.

Process in England

A recent form of somewhat similar construction developed by the Barton interests in England since the outbreak of the war uses a nickel tube about 3 in. in diameter and 10 ft. long. The catalyzer consists of a bundle of spirals of platinum foil hung in the top of the tube. The life of the catalyzer is less than three months. One troy ounce of platinum oxidizes only about 1.5 lb. of ammonia per hr. in this apparatus. The reported efficiency is 90 to 95 per cent, but a study of a large installation in France where cyanamide is converted to ammonia and that to nitric acid shows only 60 to 70 per cent for the whole, and since ammonia production from cyanamide can be carried out at a nitrogen efficiency of 96 to 98 per cent, depending upon the design of the apparatus and the skill of operation, the oxidation efficiency itself must be very low. I have no direct figures on this catalyzer efficiency.

Ostwald himself reported that his plants obtained an oxidation efficiency of 85 per cent, but my attempts to verify this over long-time operation have been fruitless. I am of the opinion as a result of my investigation that 75 per cent would be nearer. He passed his gas over the platinum at a speed of 5 m. per sec. and left the gas in contact with the catalyzer about 0.004 sec., both figures being far outside the region of our later work, and thereby confirming the low obtained efficiency of his process.

Kaiser, a Siemans & Hälske chemist, next attacked the problem. He used a platinum gauze for catalyzer and at times directly heated the air, at times activated it by silent discharge, or preferably both, then added the ammonia and passed the mixture through platinum gauze. The literature on the process is so complex as to be really unintelligible. At any rate he reported an efficiency of 150 to 220 per cent, claiming the activated air enabled the attainment of such a high temperature in the gauze catalyzer as to cause part of the nitrogen content of the activated air to unite directly with oxygen. His work was repeated by Kochman, who reported efficiencies of only 105 to 115 per cent. The answer, we later found, lay in the method of analysis used.

Europe's Premature Notice of Entering Nitrate Field

In 1908, after the first few cyanamide plants abroad were in operation, the European interests backing them placed the world on notice that they were prepared to enter the nitrate field, which up to that time had been controlled by Chilean nitrate and some small arc-process product. It looks as if this notice was based on the work of Frank and Caro which shortly afterward appeared in the form of patent literature. If so, it was very premature, as that early process never came into commercial development. The process in question used a mixture of cerium and thorium oxides as catalytic material. Like many other processes of like kind using powdered catalyzers, the process failed because the catalyst sintered and became impermeable after short use. Even as late as 1912 work was still being done on this process, the latest development being a catalyzer consisting of 99 per cent ThO_2 and 1 per cent CeO_2 and showing 65 to 70 per cent efficiency at best.

A Combination Process Evolved

The Ostwald patents, after allowance, had been cancelled in Germany and the oxidation process left open to all. Frank and Caro, after the failure of their rare earth catalyzer, turned to a combination process, passing the ammonia-air mixture through a platinum catalyzer, and then through a granular mass of cerium and thorium oxides treated with platinum chloride, and resting on a nickel screen above the platinum gauze. The experiment, carried out in a small apparatus using a gauze 4 in. in diameter, showed efficiencies of from 7 to 78 per cent, with an average of less than 50 per cent.

In July, 1913, attention of the German cyanamide interests was directed to the use of platinum alone as a catalyzer, and the best features of all previous experiments were assembled in a new type of apparatus. The preheating system of Ostwald, with the direct heating, and the gauze of Kaiser, were incorporated in the ap-

paratus shown in Fig. 2. Ammonia could be introduced with the air or at various distances under the gauze. The gauze (1060 meshes per sq.cm. and wire 0.06 mm. diameter) was only 5.5 cm. diameter, not quite all of which was active. From the meager data which came into my possession efficiencies of 41 to 91 per cent were obtained, but as ammonia passing the screen unaltered was not regarded as lost, these figures are subject to 23 to 27 per cent deduction for unaltered ammonia, making actual oxidation efficiency at a maximum only about 65 per cent. Nothing came of this work and in September and October, 1913, a new setup of the same apparatus was made. By regulating the ammonia-air mixture to between 1 : 10 and 1 : 15 by volume an average efficiency of 85 per cent less 6 per cent for unaltered ammonia was obtained.

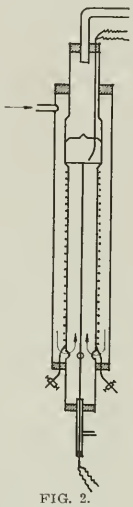


FIG. 2. OSTWALD-KAISER MODIFICATION APPARATUS

In November a larger diameter apparatus using a gauze 10 cm. diameter was put into service, but the results were not particularly encouraging, rarely exceeding 80 per cent efficiency and most of them considerably below that figure.

Experiments were carried out with smooth gauze and with gauze coated with platinum black. The latter showed little or no advantage over the smooth platinum, although slightly less ammonia seemed to pass through unchanged. Various alloys of platinum were tried and it was noted that the presence of iridium had a particularly deleterious effect. Further experiments were carried out using multiple gauzes (that is, two and three gauzes superimposed), but in no case were oxidation efficiencies as high as 85 per cent obtained. The combination of multiple gauzes and oxides of cerium and thorium gave lower results than the platinum alone.

The effect of mesh of the gauze was also studied and there was little or no difference noted in the behavior of a gauze with 3000 meshes per sq.cm., as against one with 1060 meshes. Acetylene, and also oxygen, were added to the air, but better results were obtained with air alone than with any of the mixtures, though we later, in this country, obtained different results on enriched air.

External Heat Decided On

At the conclusion of these experiments, about the end of January, 1914, this investigation on the oxidation of ammonia had not brought out anything of commercial value. The experiments were critically reviewed and it was concluded that the hot gauze radiated heat to the oncoming ammonia-air mixture and decomposed some of the ammonia. This was emphasized by the necessity of preheating the gases before they arrived at the gauze. It seemed necessary to supply external heat in some way to maintain the reaction, and it was, therefore, decided to employ electric energy transformed into heat directly in the gauze itself, to meet this deficiency of energy, and at the same time to use a cooler in front of and in as close contact with the gauze as possible, so as to bring the ammonia in the shortest possible time from the ordinary temperature to the reacting temperature, which is around 75 deg. C. The apparatus shown in Fig. 3 was constructed to accomplish this result. A long strip of platinum gauze was folded as shown and the intermediate space blocked by mica strips cemented to the gauze. This was placed 1 mm. above a circle of heavy nickel gauze, which in turn was soldered to a water-cooled copper ring. The apparatus was only a few inches in diameter, but it showed very good results, running slightly above 85 per cent in conversion efficiency. It was next duplicated on a larger scale in which the gauze had an area of 660 sq.cm. This apparatus was put into service, but ran only a few hours, when it failed mechanically, and it at no time showed an efficiency of oxidation of above 80 per cent, although the experiments carried out were the most carefully conducted of any performed.

The general program upon which this work was carried out was entirely different from that of similar investigation work as we do it in America. Strange to say, the German experts in charge of it did not seem to devote much time to analysis of the problem from from a theoretical or from a physical-chemical standpoint, but instead devoted their attention to the construction of most elaborate and intricate apparatus, in which the principles of chemical engineering were

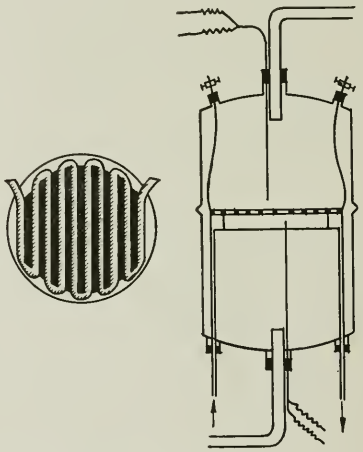


FIG. 3. ELECTRIC HEATED GAUZE APPARATUS

sacrificed to such external details as convenient existing electrical and mechanical conditions. There had not been a cleanout analysis of the problem made, as far as I would find up to the time I left Germany, in November, 1914.

Another Type of Apparatus

The construction of a different type of apparatus in which more attention was paid to chemical details next followed. A single sheet of gauze 65 x 25 cm. was especially made for this work, and very great delay in its manufacture was experienced. This gauze was housed in a metal box lined with aluminium, as shown in the detail in Fig. 4. The platinum gauze itself rested upon threads of asbestos, which in turn were carried on a nickel gauze. This nickel gauze was soldered to a frame of copper tubes through which water could be circulated. The apparatus was connected electrically to a source of low-voltage current through a rheostat

and anhydrous ammonia mixed with air was passed upward through the cooler and the gauze.

On Oct. 14, 1914, this apparatus was placed in operation. There was recovered, in the form of nitrates and nitrites, equivalent nitric acid to the extent of approximately 53 per cent of the equivalent ammonia fed to the apparatus. The apparatus failed because the gauze warped away from the cooler in places and this irregular distance resulted in very non-uniform heating. Conditions did not permit my continuing the study of this experimental work, but at the final conference in which I took part I suggested that the whole apparatus

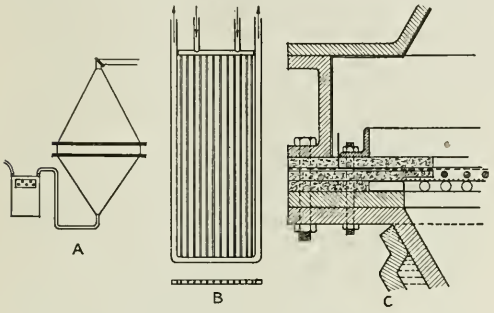


FIG. 4. A. GENERAL ASSEMBLY. B. COPPER WATER COOLER. C. DETAIL OF ASSEMBLY

would operate much better if the coolers as installed were abandoned entirely and the whole catalyzer box turned upside down. This advice was not at the time favorably received, but I believe that later, after my departure from the scene of the experiment, it was adopted and efficiencies of between 80 and 87 per cent were obtained.

This ended my direct contact with this early foreign experimental work on ammonia oxidation. The impressions I received were not encouraging, as I had not seen an apparatus function for more than a few hours at a time. The highest efficiency of conversion of ammonia to nitric oxide obtained in my presence had been only 53 per cent, and no attempt had been made to recover the nitric oxides as nitric acid, but only as nitrate-nitrite.

Further German Development

A record of further German development has been difficult to compile. On returning to Berlin I found that the commission in charge of this work had called in a new engineer, one I had not met before, but whom I knew by reputation in nitric acid work. His catalyzer was small, and consisted of a frame of refractory material about 4 in. square and ¼ in. thick. Two of these were wrapped with fine platinum wire, very close but not touching, and arranged one over the other so wires crossed at right angles. This gave the gas contact four times with the platinum in a single passage through the apparatus. The frames were arranged in a suitable housing, 24 units to a group. Each unit was supposed to make 230 g. nitric acid per hour, and consumed 4.5 amp. at 90 volts. Mechanically the apparatus was very well designed, but unfortunately it possessed a serious fault in using successive layers of catalyzer not in immediate contact with each other. This arrangement of platinum has never proved satisfactory from an efficient operating standpoint.

The writer is certain that on Jan. 1, 1915, with the exception of the old Ostwald plant, there had been nothing new erected in Germany for the oxidation of ammonia. A year later, however, very considerable installation of ammonia oxidation plants had been made, and it seems from the strong hands into which the electrically heated catalyzer had fallen that this made the greatest progress. It is believed that by the end of 1915 some form of an electrically heated catalyzer unit had been developed which was oxidizing at the rate of about 15,000 tons of ammonia per year. It is quite possible that this figure was much underestimated. In 1917, it is believed, the ammonia production in Germany had increased to around 300,000 to 400,000 tons, part of which was consumed in fertilizer, part in the direct production of ammonium nitrate and part in the oxidation of ammonia. Just how this division was made I do not know and have made no serious attempt to learn.

During my stay in Germany I found little or no information on the converting of the nitric oxide obtained from a catalyzer into nitric acid. Much of the apparatus proposed was what would be called small-scale work in this country, consisting as it did of towers of chemical stoneware, tourills and such equipment. With such apparatus for condensation, the units must have been small and inefficient, but on the other hand this type of construction lent itself to ease of assembly and a consequent great saving in time of construction. Also much of the nitric oxide was turned directly into sodium nitrate, that being a comparatively simple and easy problem. It further lent itself to the shipment of nitrate to the various powder plants already provided with the old niter pot equipment. In fact it is believed that this conversion to nitrate occurred to a very large extent throughout the war.

Imminence of War Arouses Interest Here

Toward the end of 1915, when it looked very much as if the trend of events was such that the United States was ultimately to be forced into the war, renewed interest took place in this country in the oxidation of ammonia as a source of nitric acid, and early in 1916 the writer was authorized by the American Cyanamid Co. to proceed with the design and construction of an experimental plant for studying the ammonia oxidation problem along the lines of commercializing what had heretofore been a laboratory curiosity. A considerable latitude in the choice of process was permitted, but it was essential that all equipment to be used must be capable of construction in this country. As to raw materials, we were permitted to make use of any form of ammonia on the market, but naturally we were partial to that produced from cyanamide because of a number of apparent advantages which this form of gas was then believed to possess. I am going to sketch briefly here the method of attack of the problem confronting us, as I believe the details will be of interest.

Method of Attack on Problem

The chemistry of the problem from a quantitative standpoint may be represented by the following equation:

$$4NH_3 + 5O_2 = 4NO + 6H_2O$$

This reaction will take place only in the presence of a suitable catalyzer, of which, from a study of all the previous work, platinum appeared to be the best. It is operative between 700 and 800 deg. C., giving its best results at about 750 deg. C.

The best proportion of air and ammonia for most efficient oxidation was reported by Ostwald to be a mixture containing about 10 per cent of ammonia. He, however, also expressed the opinion that a very large excess of air was advantageous. The small-scale work abroad seemed to show that an 8 per cent mixture was the most efficient to use, and we subsequently confirmed this in our large-scale work. We, however, later learned that the 8 per cent mixture was probably not the most economical for operation and preferred to work with about a 9 per cent concentration.

The combustion of a 10 per cent mixture will yield a theoretical temperature of 665 to 690 deg. C., the difference being due to variations in thermo-chemical constants used in the calculation. Assuming that the catalyzer must operate at around 750 deg. C. and that it will always radiate some heat, it is readily seen that it is absurd to consider attempting to operate the process without the addition of further heat to the catalyzer. With an 8 per cent mixture the temperature of combustion is theoretically only 550 to 580 deg. C.

The reaction

$$4NH_3 + 3O_2 = 2N_2 + 6H_2O$$

also takes place if the catalyzer is not operating properly, either due to composition or construction, or to other causes. The theoretical temperature of the flame corresponding to this reaction when using a 10 per cent ammonia mixture is 915 deg., using Nernst's data. This is somewhat higher than the actual temperature required on the screen. It is, therefore, seen that it is theoretically possible to operate the catalyzer only if from 25 to 40 per cent of the ammonia carried to the screen is burned to nitrogen, unless one has provided additional heat to the screen supplied either by regenerative methods or derived from an independent outside source.

Determining the Best Process

In looking over the methods of supplying this required heat to the catalyzer, the regenerative process of Ostwald demanded heating of the reagents to about 300 deg. C., and as at that temperature ammonia is subject to decomposition, the regeneration process did not look technically sound. We also questioned the control of a self-regenerative system in view of our lack of knowledge of the exactness of this control requirement of the process. The direct heating scheme used by Kaiser required the combustion of additional fuel and seemed to have no apparent advantages of any sort over the Ostwald system. We dismissed his so-called activation of air as of no value.

The only other method that appeared feasible to us was the direct electric heating of the catalyzer itself, and since the energy required is not very great and its cost only a very small fraction of the total operating expenses of the plant, we finally decided to adopt it.

Our next concern was the type of catalyzer. Both Kaiser and Caro had used the woven gauze or screen type with some degree of success, even though many advantages were claimed for the wire-wound frame. We adopted the screen as our first type of catalyzer and designed two forms, one of 80-mesh gauze and 0.0025-in. wire and the other of 100-mesh with wire of 0.0015 in. diameter. This gauze was to be of purest platinum, free from base metals and containing not over 0.05 per cent iridium. Three screens of each type, 13 in. wide and 26 in. long, were obtained from the American Platinum Works. The weaving was not particularly uniform, and we soon learned that the platinum contained nearly ten times the amount of iridium specified, all of which caused much trouble in the early days of our work.

Electrical Equipment

From the specifications of the gauze we figured out our electrical equipment, which was in itself quite an intricate problem in view of the lack of data on electrical conductivities of such materials as platinum gauzes. The current was received at the laboratory at 440 volts, 3 phase, 60 cycles, and distributed at this voltage for motor circuits. A portion was transferred down to 110 volts for lighting and catalyzer service, and to each catalyzer was attached an individual transformer rated 110 v. / 15.0-17.5-20.0-22.5 volts. In the high tension side was included 3 resistance grids with short-circuiting switches and a 25-point rheostat of the same total resistance as a grid. The resistance system was calculated to control the voltage on the low side of the transformer in steps of 0.05 volt over a total range of five volts or two transformer taps. This electrical system was completely revised and both cheapened and simplified in a later installation.

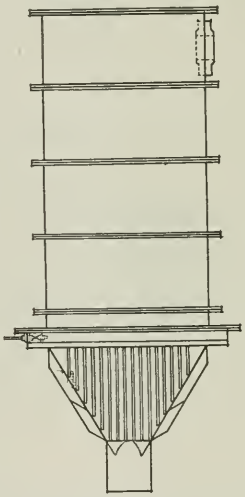


FIG. 5. MODERN CATALYZER UNIT

The catalyzer was housed in an aluminium box rectangular in section. It was stretched in a tray and packed in asbestos board, above which was assembled the sections of the box. We determined to pass the air mixture downward through the hot catalyzer, believing that method to insure more uniform distribution and flow. This necessitated some height of tower over the gauze, and not knowing just how high this should be, we built the housing in sections, each a foot high, making them interchangeable and providing four sections to each catalyzer unit. An assembly of the tower is shown in Fig. 5. Between the upper sections we placed an aluminium gauze of fine mesh and heavy wire to assist gas distribution, and at the same time carry heat to the side walls, where it was dissipated. The 4-ft. high tower seemed to be just right and has not been changed since the original design, except to eliminate the sectional feature in the later and more permanent installations. The catalyzer trays were all interchangeable and enabled us to repair and change gauzes with very little interruption to operation. After getting into operation we did not find it necessary to complicate the apparatus with a cooler, for while we believe in the use of a proper cooler, we could not design a satisfactory one.

Apparatus Performs Satisfactorily

Besides the oxidation equipment, the plant was equipped with an autoclave and ammonia apparatus for

the production of ammonia from cyanamide, gas holders and most complete measuring and indicating apparatus. Also oxidation, cooling and absorption towers for the recovery of nitric acid. Nothing was left to chance and for our efforts spent on the elaborate design we were amply repaid, for with the exception of the first platinum screens and their terminals, every piece of apparatus installed performed to the highest expected degree.

The first screens being delivered during the erection of the plant, we took one of them to the cyanamide plant in Canada and tried it out there on a small scale, absorbing the products of the reaction in caustic soda. We had learned from Ostwald that activation of the platinum was necessary, but we did not then know what it meant or how to obtain it. After running about two weeks with results showing better each day, we finally, on April 24, 1916, obtained an efficiency of oxidation of 91 per cent. In this series of experiments the highest figure obtained was 92.4 per cent, at a rate of 2 lb. NH_3 per hr. per sq.ft. of screen. The screen used weighed about 1.5 troy ounces per square foot.

While at Niagara the use of enriched air was tried in the mixture, and while it gave very good chemical results, the problem of control was so great that we did nothing to put its use into practice. By its use outside energy can be dispensed with, at least to a very large extent, but the problem of distributing a self-combustible gas over a large area of catalyzer will require more experimentation before it is worked out to a certain war-time surety.

Demonstration Plant in New Jersey

Toward the end of July, 1916, the small demonstration plant at the Ammo-Phos Works of the American Cyanamid Co. at Warners, N. J., was put into operation and it fulfilled our expectations in every way. The very light-weight screens first provided proved themselves structurally too weak for continuous heavy service, and we abandoned their use. As a matter of fact, we later increased the weight of our regular screens about 50 per cent purely for structural reasons. We also found that by passing the gas downward through the converter, only a trace of ammonia passed the screen in its original form. It was either burned or decomposed. We also learned that the capacity of a screen could be increased from the 2 lb. of ammonia per sq.ft. per hr., as obtained in our preliminary work, up to 7 lb. of ammonia per sq.ft. of screen per hr., without greatly affecting the efficiency, and under special test conditions we actually succeeded in operating up to 10 lb. of ammonia per sq.ft. of screen per hr. As a steady operating proposition, however, this latter rate would result in a lowering of the efficiency of oxidation 2 or 3 per cent, and we actually figure for most economical operation, with the high cost of ammonia, 5.5 to 6 lb. per sq.ft. of screen per hr. The highest efficiency attained in all of our development work was 96 per cent, but this was under particularly careful operating conditions at a rate of 5 lb. of ammonia per sq.ft. of screen per hour.

Operation of Plant Simple

Operation of the plant was comparatively simple after conditions were standardized. Ammonia gas and air were received at constant pressure and fed through meters and valves for mixing. The control of the mixture was a very simple matter and gave no trouble whatever. The screen attendant would turn on the current to a catalyzer and then feed in the gas mixture at a predetermined rate indicated by an orifice gage on each catalyzer tower. He would then regulate the current so as to obtain the proper temperature, at first measured by pyrometer and later by eye. Two men per shift have operated one hundred catalyzer towers over a considerable period of time, the production of nitric acid during this period averaging one-half ton of 100 per cent equivalent acid per catalyzer per day.

After eliminating the mechanical defects of the early screens we adopted a heavier type, weighing slightly less than 2½ oz. per sq.ft., and we have had some of these screens in service two years continuously on cyanamide-ammonia gas as obtained direct from the autoclave plants and without any purification whatever. These screens seem to be in just as good catalytic condition to-day as when first activated.

Life of the Platinum

The life of the platinum in this process has been the subject of much discussion. Our experience has been that a platinum catalyzer in the ordinary operation of a plant loses between 3 and 5 per cent of its weight per year. Including accidents, it looks as if a screen should give good average service for about one year, at the end of which time it will have lost less than 5 per cent of its weight. It might run longer before being melted, redrawn and rewoven, but we do not have sufficient large-scale experience at our command to give the final answer. In the early days of our experience we had many mechanical accidents and we thought this deterioration of platinum would be considerably greater than the above figures indicate, but on the basis of our experience with the large Government plant, where a very careful check of all platinum was kept, we feel certain at least of the above figures for deterioration and period of renewal. With more skilled operators and higher development of equipment, under conditions more favorable to manufacture than during the war, everything points to a very long life of catalyzer when used on cyanamide-ammonia. Coke-oven ammonia seems to present a different aspect.

Various Criticisms Advanced

Several times during the past year there have appeared in print some rather serious criticisms of ammonia derived from cyanamide, particularly in reference to its content of impurities harmful to the platinum catalyzer, as well as to its general application to oxidation. The first published criticism laid the blame on acetylene. Cyanamide-ammonia as obtained directly from the autoclaves which are producing ammonia gas for fertilizer manufacture does contain a very small fraction of 1 per cent of acetylene gas, but we never found any difficulty in oxidizing such acetylene-ammonia mixtures, provided the acetylene content did not get so high that when mixed with air the resulting gas was self-explosive when conducted to a hot catalyzer. The authors of this first criticism, after rushing into print, later found that their conclusions were entirely in error and that it was not acetylene that was causing the trouble. The true cause then became phosphine. They again rushed into print with a second paper showing the evil influence of this phosphine.

Autoclave gas undoubtedly does contain traces of phosphine at times, but the quantity is so small that present-day quantitative methods are unable to detect it with any degree of precision. Having never used any other but such autoclave gas in our laboratory and hav-

ing no trouble whatever with poisoning of the platinum catalyzer, even with screens in use two years, we did not pay very much attention to the matter at first. However, as the criticism of cyanamide-ammonia became a matter of public discussion we thoroughly investigated the whole subject and learned to our surprise that carefully purified autoclave gas, in which it was freed from acetylene, phosphine and other possible impurities, showed consistently about 10 per cent less efficiency on the same screen as when we used the raw gas.

Investigation Shows Curious Condition

This was a most curious state of affairs, and after we had firmly established this surprising difference under the most careful control possible, we learned that the platinum catalyzer seems to activate itself slowly to each particular and peculiar gas to which it is subjected during activation and that a catalyzer which had been activated on autoclave gas will not work efficiently on purified autoclave gas or on coke-oven ammonia, but requires a wholly new activation. Left to itself the period of readjustment from one form of activation to another is about ten days to two weeks, whereas our critics were subjecting their catalyzer to ten different kinds of gas on the same day and naturally drawing some very erroneous conclusions. We found a gauze activated on coke-oven ammonia could not be used efficiently on cyanamide-ammonia and that one activated on cyanamide-ammonia could not be used efficiently on coke-oven ammonia, on immediate turn-over, and that it took at least ten days of steady operation on the second variety of gas before the efficiency arose to where it was on the kind of gas on which the catalyzer was activated. We then found on examining the catalyzer closely that there were structural differences in the form which the platinum took when activated with different varieties of ammonia gas.

I have here a slide containing a bit of platinum gauze as received from the weaver and also a piece of gauze which has been in service for some time; the difference on direct vision is quite striking. I have here also a piece of the full-sized catalyzer which has been in service for a long time, showing this effect of activation. Some of our most insistent critics, when thoroughly educated by us to these facts, have later asked to be given ammonia gas high in acetylene and phosphine in the hope that through its use their own impossible apparatus could be made to operate to at least somewhere near the efficiency of our type. It has been most harmful to the progress of the development of the oxidation of ammonia in this country that such individuals as were responsible for the publication referred to above ever interested themselves in the subject. The false information spread broadcast will take much honest endeavor to discredit.

Cyanamide Process at Muscle Shoals

I can only add here that the cyanamide process was installed in the Government nitrate plant at Muscle Shoals, Ala., the whole equipment there embracing 700 catalyzers capable of easily producing, with inexperienced attention, about 250 tons of equivalent 100 per cent nitric acid per day, and which could be pushed, under emergencies and demands, to 50 per cent greater output, or 350 to 375 tons per day, without an extreme sacrifice in efficiency. The autoclave plant transformed cyanamide into ammonia at an efficiency of 97 per cent, as measured over an extended test under independent Government control.

In this test the plant was operated by men, part of whom had been trained in the American Cyanamid Co.'s experimental plant, but the chemical control was entirely exercised by Government chemists. The catalyzer efficiency for all catalyzers over this same period of time was 91.5 per cent. The absorption efficiency to the production of nitric acid was 98 per cent. This is equivalent to a total efficiency from cyanamide to nitric acid of 87 per cent, and of ammonia gas to nitric acid of practically 90 per cent. With more experienced operators, undoubtedly these figures would have been raised several per cent in the next six months. The figures are certainly a direct contradiction of a statement of some of our critics that cyanamide-ammonia cannot be oxidized at any high degree of efficiency because of its impurities. As a further matter of interest, the power requirement of the process, as installed, averaged less than 1-7 kw-hr. per lb. of nitric acid made on the catalyzer.

The gases leave the catalyzer at practically redness, although attempts are made to radiate as much heat as possible. They enter flues under the floor and are carried to coolers, where their temperature is brought down to as near normal as possible. They then pass into oxidation chambers, where a minute or two of rest converts practically all of the nitric oxide to nitrogen dioxide. This passes into absorption towers, where oxidation to nitric acid takes place and the acid is absorbed in water. Due to high concentration of nitric oxide gases, the efficiency of recovery in our absorption system is very high. In the Government plant it averaged above 98 per cent and frequently ran for long periods of time at 99 per cent. All absorption was done in water and no soda towers were used in the system whatever. The strength of acid obtained could be run as high as 50 per cent or even more, but as the material was to be used for making ammonium nitrate, no attempts at obtaining extreme concentrations were made. Since this nitric acid is extremely pure, circulation through aluminium pipes is entirely feasible and possible, and its handling with this facility at our disposal was a simple problem.

As to the cyanamide-oxidation process, it does not lend itself as readily to very small-scale installations as the old niter pot, because of the cost of installation, but where ammonia gas is available and it is not necessary to provide separate ammonia equipment, even in this case it will find some very interesting uses. For instance, at the Ammo-Phos Works of the American Cyanamid Co., a catalyzer operating on ammonia gas is supplying nitrogen oxides direct into a sulphuric acid chamber plant with very great success and at very good economy over the old potting process. Not only are the nitrogen oxides much cheaper than when made from nitrate of soda, but the consumption is very much less and the control of the chamber plant very much simplified.

Cost of Oxidation Process Not High

With ammonia gas of suitable quality obtainable at no higher unit price than equivalent nitrogen in nitrate of soda and on a reasonably large operating scale, the oxidation process will make concentrated nitric acid for at least as low a cost as the niter pot and on a large scale at a lower cost. The cost of the plant is somewhat more than for a similar sized pot plant, but

the consumption of raw materials and of labor, and the ease of manipulation, all greatly favor the ammonia oxidation plant, and it is quite likely that where the size of the installation is sufficiently great, it will offer a very serious competitor of the old nitrate of soda process.

On a fair sized plant, the operation, concentration, overhead, taxes, interest and depreciation will amount to approximately one-third of the cost of concentrated nitric acid, but this can only be accepted as a most general figure, because each plant and location must be studied individually, as these factors exert a very considerable influence on the total cost of the product. It must further be remembered that not all varieties of ammonia have shown themselves capable of oxidation. The Muscle Shoals plant furnished some rather interesting data on the cost of nitric acid and ammonium nitrate, the factory cost on the latter being less than one-half of the Government fixed price, from such figures as were obtained during the short period of partial operation of that plant. The cyanamide oxidation process has been fully protected by patents and its development and installation are still wholly in the hands of the American Cyanamid Co.

Conclusion

In conclusion, the early prophecy of Kuhlman is about to be fulfilled, and large consumers of nitric acid will do well to look closely to the oxidation of ammonia in planning their future extensions. As a war-time emergency the development in all the warring countries has given us a direct answer to its practicability. Without it Germany would not have lasted a full year of modern warfare, and the Allies themselves were forced to come to it, even with Chile open to them. When coupled with the fixation processes, its saving in transportation, raw materials, sulphuric acid, and its adaptability to large-scale units places it far ahead of the older nitric acid process, and for certain special applications it has no competitor. It was a long time coming to the front, but I believe it has now reached the point where future extensions and improvements will be rapid, and I anticipate it will soon be producing its better product alongside its older competitor on a fair-sized scale.

Lead Poisoning

THE susceptibility of women workers in lead industries to certain forms of lead poisoning and the dangerous effects of this occupational poison on their children are two important facts brought out in a bulletin on Women in the Lead Industry (Bulletin No. 253) just issued by the Bureau of Labor Statistics of the U. S. Department of Labor. Lead, which is by far the most common industrial poison, is responsible for no less than 95 per cent of all the poisoning due to occupation, according to Teleky, a German authority. In this country lead poisoning is a fairly familiar occurrence, but until comparatively recent times it has not been at all common among women workers because relatively few women have been employed in lead industries. Now, however, women are beginning to enter occupations in which exposure to lead is inevitable, and it is regarded as very important to look carefully into the question of their employment in such occupations and to determine whether it will be better to safeguard them by requiring employers to use every known means to reduce or eliminate the hazard of lead poisoning or by prohibiting the employment of women entirely in those occupations in which lead poisoning constitutes a considerable hazard.

British authorities hold that women are more susceptible to poisoning by lead than men, and legislation in Great Britain has followed these authorities, with the result that women are barred from some of the most dangerous lead work. On the other hand, the Germans believe that the apparently greater susceptibility of women to lead poisoning is to be explained not by their sex, but by the fact that they are usually more poverty-stricken than the men, are undernourished and obliged to do work for their families in addition to their factory work. Observations in the pottery industry in this country seem to bear out the German theory, for while a much larger proportion of women than of men were found suffering from lead poisoning in the East Liverpool and Trenton districts, it was also found that in these districts the men are members of a strong union, are well paid, and have good living conditions, while the women are unorganized, underpaid, poorly housed, poorly fed, and subject to the worry and strain of supporting dependents on low wages. In the unorganized pottery fields, in the tile works, and in the art potteries of the Zanesville district the men and women were in the same economic class, all making low wages, with everything which that implies, and here the rate of lead poisoning was slightly greater among the men.

Whether or not women are more susceptible to lead poisoning than men, the records show that they are more likely to have the nervous form of lead poisoning than are men. Women suffer more from lead convulsions and lead blindness, men from lead paralysis and lead colic.

The report points out that "women who suffer from lead poisoning are more likely to be sterile and to have miscarriages and stillbirths than are women not exposed to lead. If they bear living children these are more likely to die during the first year of life than are the children of women who have never been exposed to lead." Striking proof of this fact is contained in the bulletin. "Everyone will admit that a poison which may destroy or cripple a woman's children is a far more dangerous poison than one which only injures the woman herself. This is why it is necessary to forbid the entrance of women into the more dangerous kinds of lead work and to surround their employment in the less dangerous ones with all possible precautions," says the bulletin.

The bulletin opens with a brief description of lead poisoning, noting some of the well-known symptoms by which it is easily recognized, but calling attention as well to symptoms which are less clear and which prompt the statement that "there is no known poisonous substance which can give rise to such a variety of symptoms as lead." A number of typical cases are briefly described. An important fact brought out in the discussion of lead poisoning is the difference in susceptibility of workers. For example, in one white lead factory the records show that one of the employees began to feel symptoms of lead poisoning at the end of two weeks' time, and died after five and a half months. In the same factory was a man who had worked in clouds of white lead dust for 32 years, ever since he was a boy of 12, and had felt no ill effects.

Flaky Fractures and Their Possible Elimination

A Critical Review of the Literature Bearing Upon Oxides and Other Inclusions in Steel, Together With an Application of the Principles of Physical Chemistry to Conditions in a Steel Melt—Deductions of Technical Importance Are Drawn Which Where Applied Reduced Failures

By HAAKON STYRI

IN CONNECTION with the hypothesis that flakes are largely due to non-metallic inclusions, it is of interest to review in part the previous work of other investigators concerning inclusions and crackings in steel.

Capt. H. G. Howarth,[7] on examining fractures, found inclusions sometimes visible to the naked eye, but often so small that a handglass or microscope had to be used for detection. The color varied from sulphur-yellow to green, or to cream and bronze, and they sometimes covered 10 per cent of the area. They were mostly elongated, but had also irregular shapes. Laminated fracture and a small reduction of area with external cracks in the specimen were associated with them. They were more common in large than in small forgings, which were reduced from 1 to 5, and were mostly found in the bottom end of large ingots, while the streaks were always placed longitudinally. He had not been able to detect a single greenish defect in longitudinal tests. He notes the optical similarity of detached pieces of the slag particles from the fractures to manganese silicate slag.

Stead in discussing the above paper mentioned the reaction between silicon, manganese and oxygen and gave the following analysis of a residue from dissolving steel in dilute HNO_3: SiO_2, 46.6; MnO, 48.08; Al_2O_3, 3.39; FeO, etc., 1.92.

Fay[8] shows that MnS causes a fibrous structure in fractures and gives an example of a 12-in. rifle where this had caused fracture during service in spite of excellent heat treatment.

E. F. Law[9] discusses the different forms of "non-metallic impurities" and advocates the necessity of proving by analysis whether or not silicon and manganese are present as oxides, and gives examples of blister sheets where those with high oxygen have the poorest properties.

J. E. Stead[10] found on welding blowholes and cavities in ingots that for complete welding the surfaces must be in actual contact at a temperature above 950 deg. C. (and preferably at least 1100) and that disruption can be caused by faulty forging. Morgan said in discussion that surfaces or blowholes would not necessarily come in contact during mechanical work: they may only be distorted. Stead remarked later that segregations of S (MnS) may cause premature fracture on transverse test even when blowholes were perfectly welded, and that FeO does not prevent welding in certain cases where sufficient carbon is present, because the oxygen can be consumed in decarbonizing the surrounding material.

Rogers[11] shows the presence and influence of MnS in fractures by means of a gelatine emulsion of silver bromide.

J. N. Kilby[12] gives two causes for "oxides" in steel melting: they are formed during melting and not removed, or they are introduced by excessive or erratic feeding of ore. He advocates having as high as 2 per cent silicon in the total charge from the start, and the using of limestone to reduce the amount of FeO in the slag, thereby increasing the manganese yield. Slag with CaO will act as a better absorbent of extraneous matter existing in steel and thus minimize the oxidation of manganese. When slag is added to the charge it will protect the bath from oxidation. The hearth condition is important in the acid open-hearth process, whether the hearth is saturated with oxides or not. He also gives evidence that teaming at a correct rate is necessary to prevent the ingots from cracking.

McWilliam and Hatfield[13] in a paper on the elimination of silicon in acid open-hearth show how the amount of silicon in steel corresponds in general to the amount of silica in the slag at normal bath temperatures.

Boylston,[14] studying the relative merits of various agents for deoxidation of steel, comes to the conclusion that no startling difference is noticeable in their action.

J. E. Howard,[15] discussing sound steel ingots, mentions the impossibility of welding across inclusions and the consequent defects from rolling them into streaks, forming laminations and causing danger in transverse tests. Petinot, in the discussion, also noted the danger from oxidation products of aluminium and silicon, and says the use of titanium is less dangerous because the TiO_2 formed will help flux the other slag inclusions provided sufficient time is given in the ladle. With less inclusions to contaminate the surface of the pipe, this will be easier to weld. Zimmerschied listed defects in automobile steels, increasing in importance to the last—ingotism, seaminess, pipes, segregates, non-metallic inclusions—while Dudley said segregation is decidedly reduced with ferrotitanium, and is not so marked with silicon.

Hibbard[16] considers the distribution of solid non-metallic impurities in steel to be important; they are dangerous if present as pellicules in the crystal joints even if the total amount is small, and the influence of the impurities is most important during hot work, because they make the steel brittle. He cites a case[17]

[7] *Journal*, Iron and Steel Institute, 1905, p. 301.
[8] *Proc.*, American Institute for Testing Materials, 1908.
[9] *Journal*, Iron and Steel Institute, 1907, p. 94.
[10] *Journal*, Iron and Steel Institute, 1911, I; p. 54 and p. 104.
[11] *Journal*, Iron and Steel Institute, 192, I; p. 379.
[12] *Journal*, Iron and Steel Institute, 1907, II; p. 69; 1918, p. 365.
[13] *Journal*, Iron and Steel Institute, 1902, I; p. 54; 1904, II, p. 206.
[14] *Carnegie Scholarship Memoirs*, 1916, p. 102.
[15] *Trans.*, American Institute of Mining Engineers, 1913, I, p. 490 et seq.
[16] *Trans.*, American Institute of Mining Engineers, 1911, p. 321.
[17] *Revue de Metallurgie*, 1912, p. 1103.

where improvement in spring steel was obtained by adding pig iron to the melt and letting it boil, and says that agitation is of little use if the inclusions do not coalesce, for which time must be given. The particles in the bottom of an ingot do not get time to assemble before the freezing of the steel.

Rosenhain,[18] in reviewing the subject of inclusions for the International Congress for Testing Materials, says that the fundamental question of solubility of slags in steel is not solved, and refers to Hibbard's conclusion that inclusions are due to a combination of the purifiers manganese and silicon with oxygen sulphur and to Stead's idea that oxygen is taken up by steel on passage through air in pouring. He proposes attempting to coalesce small globules of slag in a manner related to the glassmakers' practice of introducing a moist potato in the melt to produce large gas bubbles. He also mentions banding in plates as being due to ferrite crystallization on elongated foreign particles and compares this with the persistence of inclusions in ferrite bands in welds.

Stead[19] showed how a coarse network of inclusions persisted after heat treatment which destroyed the primitive ferrite network, while Portevin and Bernard[20] gave an example of a coarse ferrite network containing small holes with consequent brittleness persisting after quenching in water at 850 deg. C. and drawing to 700 deg. C.

Ziegler[21] cites evidence for the idea that inclusions serve as crystallization centers for alpha ferrite.

Stead[22] argued that inclusions alone do not act as crystallization centers for ferrite. Ferrite streaks result rather from an unequal phosphorus distribution during the freezing of the ingot, incidentally associated with inclusions enveloping the primary crystals and worked into streaks by mechanical treatment. Phosphorus can be evenly distributed by prolonged heating above 1200 deg. C. Brearley, in discussing, said that intimate contact must be necessary to induce ferrite crystallization on foreign particles, and Rosenhain remarked that nuclei must be isomorphous to iron to induce such crystallization.

N. J. Belaiew[23] says that the macrostructure of a specimen of steel is a result of nonhomogeneity in chemical composition of crystals solidifying at different points. Therefore it cannot be changed by ordinary treatment—mechanical work will only distort, and temperature, if high enough, will only produce local change within the macrocrystal.

F. Robin[24] believes cracking is mostly due to foreign matter or small cavities, since his experiments showed the most fissure-formation in unclean steel. He also observes that fissures formed in spite of expert forging followed inclusions. By forging nickel steel (Ni 2.5%, Cr 1.5%, C 0.5%) at 1100 deg. C. he produced fissures which did not follow martensite lines.

Portevin and Bernard,[25] in discussing the interrelation between mechanical properties and Widmanstättian structure, show how W-bands and martensite are related, and give in some shock tests an example of poor quality of steel where ferrite is partly left in Widmanstättian structure after forging, and how heat treatment can improve this. Belaiew noted that certain Russian artillery contracts include a paragraph that forgings may be rejected if Widmanstättian structure can be found at a magnification of 50.

G. Charpy[26] describes experiments to show the uneven amount of work the particles in an ingot get in forgings as compared with rolling. He says on test-pieces taken from forgings on transverse planes with different amount of reduction that "there is a dominant reason to forego comparison of such test-pieces owing to the variations in composition and in structure which are inevitable in transverse sections of any ingot." He shows further how the elongation and reduction in area of transverse test-pieces are reduced with an increasing amount of reduction in work when compared with corresponding properties of longitudinal test pieces, and remarks that this difference will increase very much with an increased amount of impurities. Impact tests showed the influence of the direction of the fracture to the direction of the rolling, with the best results where the stress is parallel to the direction of work.

H. M. Howe[27] in discussing dull porcellanic fibrous fractures, remarks that lengthwise banding of ferrite accompanies fibrous fractures and offers itself as their natural cause. Furthermore, they are ultimately due to slag in steel of plastic origin; but in steel from liquid origin are due to dendritic segregations (including carbon, phosphorus, manganese, slag and blowholes) drawn out lengthwise in rolling and forging.

A. McCance[28] estimates that fully 90 per cent of the failures he has noticed are due to nonmetallic inclusions. Steel which is heat-treated to brittleness starts cracking from such inclusions, but this effect is negligible in steels with proper heat treatment, although inclusions in groups are detrimental. He calls attention to Inglis' work[29] showing that stresses existing in metal surrounding holes are not equally distributed, but are greatest at the end of the axis, which is normal to the direction of pull. Proximate calculation shows that small particles cannot rise to the surface in the time given for ingot solidification. Viscosity of the steel is also an important factor, and therefore he advocates a high tapping temperature. Brinell, Hachney and Stead believe that different amounts of manganese are necessary to take care of the sulphur in steel, while Röhl[30] notes that MnS is insoluble in steel; consequently McCance says it is unlikely that FeS is not completely reduced by manganese.

Steinberg,[31] however, shows that artificial inclusions of sulphides in steels will distribute equally on freezing from the liquid and grow smaller on quenching from high temperature, therefore some sulphur must go into solution even before fusion. McCance also gives an experiment on Al_2S_3 artificially placed in steel, which shows some reaction, since the steel was welded across the sulphide inclusion.

McCance further states that there is a relation between the heats of formation of the oxides and the degree to which they can be reduced, and quotes Levy's[32] experiment, placing slag ($2MnOSiO_2$) in contact for 30

[18] *Revue de Metallurgie*, 1912, p. 988.
[19] *Journal*, Iron and Steel Institute; 1905, II, p. 84.
[20] *Revue de Metallurgie*, 1915, p. 155.
[21] *Revue de Metallurgie*, Sept., 1911.
[22] *Journal*, Iron and Steel Institute, 1918, p. 287.
[23] *Revue de Metallurgie*, 1917.
[24] *Revue de Metallurgie*, 1911, p. 436.
[25] *Revue de Metallurgie*, 1912, p. 544.
[26] *Engineering*, 1918, p. 310.
[27] "The Metallography of Steel and Cast Iron," pp. 539, 546.
[28] *Journal*, Iron and Steel Institute, 1918, p. 239.
[29] *Proc.*, Institute of Naval Architects, 1910.
[30] *Carnegie Scholarship Memoirs*, 1912.
[31] *Revue de Metallurgie*, Extracts, 1914, p. 313.
[32] *Carnegie Scholarship Memoirs*, 1911.

min. with siliceous cast iron, with the result that manganese increased in the iron, and SiO_2 increased in the slag $\frac{1}{3}$ to $\frac{1}{2}$ in quantity. Slag in contact with steel and the inclusions will ultimately be converted into manganese silicate. The loss of manganese in acid open-hearth practice is due to a reduction of FeO by manganese. He emphasizes the influence of slag constitution and temperature on the ease of elimination of impurities, giving an example of how greater fluidity improves the steel. (He apparently means, however, that boiling in the bath will cause slag particles to mix into the steel, for the same reason that steel globules are found in the slag, but only the latter occurrence can be normal, since boiling gives an upward movement of gas bubbles.) He says further that oxidation of carbon can only take place when silicon and manganese have been reduced to traces, while the solubility of FeO in steel must be independent of outside pressure, in spite of his reference to Baraduc-Muller,[33] that CO (and hydrogen) are given off under reduced pressure.

The many authors cited above do not use the term "flake"; but it is evident to the student that the causes of failures in the steels which they have investigated are often similar to those which have caused flaky fractures of steels described in the first portion of this paper. In this experimental work the author has come to the conclusion that the predominant cause for flakes is nonmetallic inclusions, which will be the more dangerous the larger the area they present at right angles to the direction of stress and the sharper they cut.

Flakes may also be caused by incipient cracks formed through faulty pouring, heating or forging, which by the way, are more easily formed when inclusions are present. In general, the high elastic limit and tensile strength in rejected testbars indicate that inclusions and incipient cracks ordinarily are only spots from which the irregularity in the fracture (flakes) propagates during testing. Blowholes and segregation may occasionally cause flakes.

Since no distinct microstructure has been found associated with flakes, the heat treatment generally given to commercial steel will not cause flakes, nor can it eliminate them; but proper heat treatment will of course improve the physical qualities of the sound portions of flaky steel and lessen the tendency to crack formation.

With the principal causes for flakes and corresponding failures identified it will now be proper to discuss the factors that will influence their elimination.

Equilibrium of Oxides in Iron

We know from the many researches on inclusions that they are oxides, silicates and sulphides. They are probably in general not inclusions of the same composition as the furnace or ladle slag. Sulphides are sometimes identified and in exceptional cases, when quantitative analysis can be made, the difference in composition is shown as in the above stated by Stead and in another, furnished the author by party F, which gives SiO 41.8, Fe_2O_3 1.8, Al_2O_3 17.15, MnO 29.3, CaO 0.5, MgO 0.54, with the ordinary slag SiO_2 51.4, Fe_2O_3 22.2, MnO 19.9, CaO 3.1. For many cases, examined in the first part of this paper, different kinds of particles were found in the same fracture.

Inclusions may have been caused mechanically in tapping a pouring, but ordinarily inherent conditions in the molten steel is the cause. A very good idea of the formation of the inclusions may be had if we utilize in part H. Le Chatelier's admirable treatise on the application of pure science to metallurgy,[34] a work which is hardly known in English literature. Le Chatelier arrived at the basic principle for the reduction of oxides by applying the dissociation law. Thus the partial pressure of oxygen as it varies with the temperature can be calculated by means of Carnot-Clapeyron's formula applying to simple reactions:

$$(1) \qquad -\frac{L}{T} + 0.002 \ln P = 0.032$$

where L is the heat of the reaction, T the absolute temperature, and P the dissociation pressure. Thus at 1600 deg. C. we have for the dissociation of iron oxide

$$(2) \qquad 2FeO = 2Fe + O_2 - 130 \text{ cal.}$$

Substituting in equation (1)

$$-\frac{-130}{1873} + 0.002 \ln P = 0.032 \qquad \text{whence}$$

$$\ln P = -18.7 \qquad \text{or} \qquad \log. P = -8$$

$$P = 10^{-8}$$

which as noted above is the partial pressure of the oxygen in c.g.s. units for free iron oxide at 1600 deg. C. In a saturated solution of iron oxide in steel at 1600 deg. C., with a hypothetical cover of FeO and where equilibrium exists, the partial pressure of the oxygen in solution must be equal to the dissociation pressure of free iron oxide at the same temperature. If less oxygen than corresponding to saturation is dissolved in the steel, some more FeO from the slag will go in solution. Utilizing the law of mass action, one can find the partial pressure of the oxygen at concentration less than saturation, when there is no slag cover, thus:

Equation:	$2FeO$	$\leftrightarrows$	$2Fe$	$+$	O_2
Concentrations:	a		b		p

$$(3) \qquad \frac{a^2}{b^2 p} = \frac{1}{k} \text{ where } k \text{ is a constant.}$$

b may be considered equal to 1, since the concentration of iron varies but little, then

$$(4) \qquad p = ka^2$$

and at saturation

$$(5) \qquad P = kA^2$$

Le Chatelier gives the solubility of FeO in steel at 1600 deg C. as 1.1 per cent (equivalent to 0.244 per cent O), while P has been already calculated to be 10^{-8} Dividing (4) by (5)

$$\frac{p}{P} = \frac{a^2}{A^2}$$

Substituting known values and letting the concentration of FeO represent the concentration of O since it makes no difference mathematically and facilitates the following calculation:

$$(6) \qquad p = \frac{10^{-8}}{0.244^2} a^2$$

From this equation the partial pressure of different concentrations of oxygen in steel can be calculated. If the metal is in contact with a slag of another composition than pure FeO, which is the condition assumed in deriving the above equation, the equilibrium would demand less amount of oxygen in the steel (less oxygen pressure) even disregarding the influence of the heat of reaction between FeO and other components of the slag, because of the lower concentration of FeO in the slag, and it should be possible in practice to arrive at the oxygen pressure at equilibrium, at least numerically,

[33] *Carnegie Scholarship Memoirs*, 1914, p. 216.

[34] *Revue de Metallurgie*, 1912; "La Silice," p. 558.

by analyzing for oxygen in steel and the corresponding slag of ferrous or complex silicates. Pickard[35] and Schirmer Kichline[36] therefore do not give the maximum solubility of oxygen in steel, when they state 0.092 per cent O present, but possibly the equilibrium for their particular slags, of which analyses were not given.

To find the influence of an addition of manganese to the bath at 1600 deg. C. we will further with Le Chatelier consider the equation

$$2MnO = 2Mn + O_2 - 182 \text{ cal.}$$

Conc. c d e

Substituting in equation (1) and solving,

$$E = 10^{-14}$$

which is the dissociation pressure for free manganese oxide.

By the law of mass action

$$\frac{c^2}{d^2 e} = \frac{1}{k_1} \tag{7}$$

In equation (7) d, the concentration of manganese in the steel under a manganiferous slag, can be varied and c, the concentration of MnO in the slag, can be considered maintained constantly equal to unity. Hence

$$e = \frac{k_1}{d^2} \tag{8}$$

In case there is no iron in the metal, that is, for pure manganese, $d = 1$; equation (8) further simplifies into

$$E = k_1 \tag{9}$$

$$e = \frac{10^{-14}}{d^2} \tag{10}$$

That is to say, the dissociation pressure of manganese oxide in the steel, or in other words the partial pressure of O dissolved, varies inversely as the square of the concentration of manganese in the steel.

It is now easy to show graphically how manganese and oxygen will influence one another when dissolved in steel. For this purpose Curve I in the accompanying

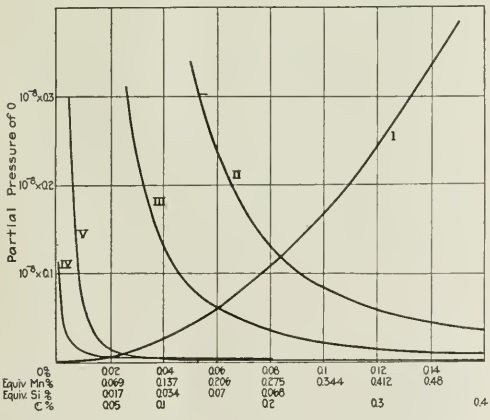


chart has been calculated by the author after formula (6), giving the oxygen pressure for different concentrations of O in steel, and Curve II after formula (10) for the partial pressure of the oxygen which can be in equilibrium with different concentrations of manganese in steel. (The abcissæ give the manganese equivalent of oxygen to facilitate graphic calculation; equal horizontal lengths will give the amount of manganese necessary for the reduction of oxygen.)

If we change the concentration of MnO in the slag and disregard the influence of the heat of reaction between MnO and other components, we can see from equation (7) that the oxygen pressure and accordingly the concentration of oxygen must decrease with the square of the concentration of MnO in the slag for equilibrium. Curve III is therefore calculated for 50 molecular per cent MnO in the slag.

For silicon a similar calculation may be made to that for manganese, noting that the heat of the reaction at 1600 deg. C. is 180 cal. The result is

$$h = \frac{10^{-13.7}}{g} \tag{11}$$

where h is the dissociation pressure (or partial pressure of oxygen) of silica and g is the concentration of silicon in the steel, and the two are inversely proportional to each other. Curve IV is calculated for the partial pressure of oxygen in the bath which is in equilibrium with varying amounts of silicon, and as before the silicon equivalent of oxygen is noted on the horizontal axis.

Further, consider the equation at 1600 deg. C.

$$FeO + C = Fe + CO - 36 \text{ cal.}$$

Concentrations: i j m n

By equation (1)

$$n = 10^{2.78} = 600 \text{ atmospheres}$$

the pressure of CO in equilibrium with FeO, carbon and iron.

Generally when iron oxide is reduced by carbon CO_2 will be found simultaneously with CO in amounts varying little with the temperature at about $\frac{1}{3}$ the total. The solubility of carbon in steel at 1600 deg. C. is given by Le Chatalier at approximately 5.5 per cent, and of oxygen 0.244 per cent, and both can be present simultaneously at this concentration if the total gas pressure ($CO + CO_2$) is 870 atmospheres. Substituting these values in the mass-action equation, and letting m equal unity

$$K_3 = \frac{ij}{mn} = \frac{0.244 \times 5.5}{600}$$

For the total gas pressure $CO + CO_2 = 1$ atmosphere, the partial pressure of CO is equal to 0.7 atmosphere, and we can calculate the concentration of oxygen and the corresponding oxygen pressure of the CO in steel for different amounts of carbon, as represented by Curve V, since the oxygen-pressure of CO and of FeO must be equal at equilibrium. The abscissæ in this case are chosen to make the amounts of carbon most commonly found in the bath come within the limits of the chart. If the gases CO and CO_2 should need a higher pressure than 1 atmosphere to escape from the bath, the ordinates of Curve V would be correspondingly higher. On the other hand, if we introduce another gas in the steel, for instance, by poling, we facilitate the formation of CO and CO_2 since they do not then alone carry the whole atmospheric pressure + the hydrostatic pressure of the steel above.

Practical Deductions From the Curves

The chart tells clearly that manganese alone is a comparatively weak deoxidizer, but has a much stronger action if some other deoxidizer like silicon is present. This for the reason that the MnO formed will then combine with the SiO_2 formed simultaneously, thus re-

[35] *Carnegie Scholarship Memoirs*, 1916, p. 74.

[36] *Trans.*, American Institute of Mining Engineers, 1913, p. 436.

ducing the concentration of both MnO and SiO_2 in the slag, whereby in turn the deoxidizing power of the metals is increased. There is the further advantage of adding manganese and silicon to the bath together, since the resulting slag will be more fluid and it can more easily combine into larger drops and rise to the surface. Any other addition of deoxidizer which forms an oxide which will combine to a more fluid slag will be of advantage.

We see further from the chart that carbon is a stronger deoxidizer than manganese, and weaker than silicon for low concentrations but stronger at higher concentrations. The numerical values of the chart must of course be considered with reserve since so little experimental work has been done along this line. This will explain why silicon under certain conditions can be reduced back into the bath.

The chart represents only the conditions at 1600 deg. C. To calculate for other temperatures, one would have to know the corresponding solubilities of oxygen and carbon. In general, we know from the formula given above that the dissociation pressures of the metallic oxides increase with temperature and also from v. Juptner's calculations[37] that the dissociation of CO changes little with temperature.

It is easy now to understand how the strong reducing power of carbon can be utilized to advantage in refining steel. In the melting-down period when the temperature is low, oxygen will principally combine with silicon and manganese to form small slag globuli in the bath. After the bath is liquid, as the temperature increases the oxygen pressure of these oxides will increase, with the result that carbon will gradually get a stronger reducing action on them. CO will be formed and the bath commence to boil, with the consequence that the small gas bubbles drive the nonreduced slag particles with them up through the steel just like drops of rain take dust particles out of the air. For this reason boiling must be considered the best method of purifying steel, and more so in nickel than in carbon-steel, since the viscosity of the former is higher, and therefore the slag particles included will have the more difficulty in liquating and rising to the surface. It is wrong to "kill" the boil by introducing the ordinary deoxidizers manganese and silicon, because the very oxides are then formed which we want to eliminate. On the other hand, boiling should not continue until the carbon gets too low, with the result that oxygen would be taken from the slag (which in open-hearth practice is always to some extent oxidizing), necessitating in turn the addition of more deoxidizer to properly kill the steel before tapping if time cannot be given to deoxidize with wash metal. Boiling should be diminished toward the end so that only the amount of alloys should be added which is necessary to prevent gas-evolution upon solidfication. If no deoxidizers are added the gradual concentration of carbon and oxygen toward the center of the ingot during the solidification period would otherwise cause such gas-evolution.

Oxidation products are not the only foreign impurities in steel. They also come from the slag and from small particles in spouts, runners, ladles and molds, which should all be kept strictly clean. Other sources, much worse, have come to the author's notice; for instance, the throw of lime with the stream of steel in the ladle in order to get a thick slag cover.

[37] *Journal*, Iron and Steel Institute, 1907, p. 59.

Only few words need to be said about the other main impurity in steel—sulphur—since the reactions between it and iron, manganese and aluminium are exactly similar to the reactions between oxygen and iron, manganese and silicon. But for the lack of some experimental data a chart like the one given here could be calculated for sulphur, and it would show how desulphurization (sulphur pressure) would depend on the heat of reaction of the sulphides. It is incorrect to say that MnS is insoluble in steel. MnS will dissolve until the "solubility product" of manganese and sulphur prevents further solution, a point which of course is different in solid and liquid steel. The same holds true for Al_2S_3, explaining how McCance found Al_2S_3 distributed in steel after forging.

Casting Practice

Casting of the steel was treated to some extent in the first part of this paper. A little may be added about the desirability of letting the ingot freeze after the onion or after the landlocking-type, and about the further treatment of the ingot. The slow cooling which produces the onion-type will tend to push the impurities towards the center, increasing also the segregation of phosphorus and carbon. H. M. Howe prefers freezing after the landlocking-type, casting the steel at low temperature in a cold mold. In that case the inclusions will be interlocked within the columnar structure and will be more evenly distributed. Thus the segregation will be less, but fewer particles will get time to rise and "slag off."

The columnar or landlocking structure will be deepest and most pronounced in the bottom part of the ingot because the mold is thickest there, and coldest when the pouring starts and it is found that the bottom end of the ingots gives more failures from flaky test-pieces than the top end. The author, for this reason, would prefer freezing after the onion-type, using hot molds or sand molds.

Columnar surface structure is weaker against strain in a tangential direction arising when the inner layers of the ingot pass the critical range. To prevent failure at this time it would be advisable to strip the ingot as soon as possible and put it in a soaking pit, thus equalizing the temperature before the outer layer has passed the critical. The depth of the columnar structure, which depends on the heat gradient in cooling, will probably influence the tendency to crack, and it will therefore be important to be able to calculate beforehand the temperature gradients for different sizes of ingots, molds and temperatures. Some trials in this direction have shown the author that the time-temperature curves for any point will be expressed by a series of exponential functions and probably too cumbersome to apply. Fletcher[38] has made approximate calculations for the same purpose, not considering, however, the heat conductivity.

The ingot should preferably be forged direct from the soaking pit. If it must be cooled down, it should be done in the pit or in ashes, while subsequent reheating must be done very carefully so that the inside does not crack or is left too cold for the subsequent works, which will then easily start interior cracks. With proper heating, forging is better done between V-dies than between flat dies, since the angle of flaw in the material then will change when the piece is turned and forged in the new position.

[38] *Engineering*, 1918, p. 342.

The principal cause for flakes, which generally are found associated with low physical test values, was found to be nonmetallic inclusions. In making the steel, therefore, the greatest care should be taken to eliminate such inclusions as much as possible by a properly conducted boil which should die down without the addition of deoxidizers, when the steel is nearing the correct carbon content. When the oxygen present in the steel is reduced to the least practicable amount by the carbon (or added wash metal), and in good time before tapping, deoxidizers should be added only in sufficient quantity to prevent gas evolution ("rising") when the steel is poured—manganese and similar alloys of course in quantities wanted for physical properties.

Likewise much care should be taken that inclusions from other sources are not introduced, particularly when tapping and pouring.

It is theoretically and practically impossible to get a steel absolutely free from nonmetallic inclusions; the endeavor must be toward eliminating them as much as possible technically. Blowholes and strong local segregations should not be present in steel which is properly made.

The subsequent treatment of the steel in pouring, heating and forging is further of great importance, because cracking may start when strains set in from uneven heating or cooling, particularly dangerous at the period of critical contraction or expansion; or when strains are produced by improper forging.

Due to the fact that the inclusions present are most dangerous when the stress is applied at right angles to their largest section, it will be best to have as little reduction done as practicable so that the inclusions will retain the spherical form as nearly as possible when the forgings will be subjected to transverse stress.

Heat treatment can never eliminate inclusions and therefore never entirely prevent the formation of flakes; but a proper heat treatment which brings the steel surrounding the slag particles in the best condition to resist the propagation of cracks on straining the material will naturally improve the service qualities of such steel. Repeating the heat treatment and taking new test bars until good tests are found is unsafe for the same reason if flakes are once found in a steel. A bar taken from a nearby place may give a poor result, since the distribution of foreign particles or cracks is never even. It must be considered better practice to take tests from the forging before it is machined, and reject the piece entirely if fractures of test bars show flakes with nonmetallic inclusions when examined with the binocular microscope.

Carnegie Institute of Technology,
Pittsburgh, Pa.

Request for Quotation on Borax

Four thousand pounds of borax, of a grade suitable for use for the killing of flies, are required by the War Department. Prices on this material are desired f.o.b. place of storage or production and f.o.b. Camp Jackson, S. C. Bids will be received until 10 a.m., April 22, 1919, and must include: Discount for cash in ten days, delivery, description of containers and packing, approximate shipping cubage and weight, specifications that will be fullfilled by the material. Address reply to: Paints Branch of Raw Materials Division, Attention of Capt. A. O. Van Suetendael, Munitions Building, Washington, D. C.

Metal Strapping on Wooden Boxes

One of the quickest and cheapest methods of adding to the strength of a wooden box is to wrap it with thin, flat metal straps. The ability of a box to withstand the hazards of transportation may thus be increased several hundred per cent. Tests made at the Forest Products Laboratory for the War Department have provided some information as to how a box should be strapped to add most to its durability.

The best place to apply the strap is apparently about $\frac{1}{4}$ of the length of the box from the end. The strapping is preferably nailed at each edge of the box to hold it in place, having, of course, been drawn snug by special tools for that purpose. Nailing the strap in place works well on boxes made of lumber $\frac{3}{8}$ inch or more in thickness, but cannot be successfully used on thinner material because the nail splits the board. On thin boxes it is necessary to join the two ends of the strap (for which purpose there are several devices), thus making a metal band around the box held in place by tension.

Depending on tension alone to keep the strap in place is, however, open to one serious objection. Unless the box is constructed of dry lumber, shrinkage reduces its circumference to such an extent that the metal strap is no longer tight. This action not only reduces the effectiveness of the strap, but commonly permits it to slip over the end of the box. A shrinkage in moisture content of 10 per cent will permit the straps to fall off when the boxes are subjected to the ordinary hazards of transportation. A shrinkage of 5 per cent will loosen the straps considerably, but the shrinkage is rarely enough to permit them to fall off.

The effect of shrinkage of the box is also serious when the straps are nailed at any point, since it causes them to buckle or "festoon." The reinforcing effect of the straps is thus diminished and the box becomes dangerous to handle. It is important, therefore, that metal-strapped boxes which are to be in transit or storage for any length of time should be built of dry lumber.

Recovery of Waste Paraffined Paper

In the process of manufacturing paraffined paper and various products such as cartons, cups and wrappers, large quantities of impregnated paper stock are now wasted. In the making of paraffined paper alone, it is estimated, the daily waste amounts to 8 or 10 tons.

An opportunity for the recovery of a large part of such waste paper and impregnating material is offered in the application of a method recently developed at the Forest Products Laboratory, providing mill trials are as successful as the semi-commercial laboratory work indicates.

The recovery method consists in treating the finely shredded waste with petroleum oil solvent in a series of extractions, which removes practically all the paraffine. The paraffine is afterward separated from the solvent, which is used again. The solvent left clinging to the extracted paper is also recovered by a steaming process.

A paper fully as strong as the original can be made from the remaining pulp.

Bituminous Roofing Materials and Construction—II

Description of the Types of Bituminous Roofing: Built-up Felt Pitch, Rubber Roofing and Felt Base Shingles—Comparative Tests for Roofing Materials for Thickness, Tensile Strength, Absorption of Moisture, Pliability, Volatility and Fillers—Specifications

By George Landis Wilson

SATURATED felts are used for what are known as "built-up" roofs; that is, roofs that are constructed or "built up" of the roof deck to fit the building. Such roofs when surfaced with gravel or crushed stone are popularly known under the generic term of "gravel roofs." The terms 5-ply, 4-ply and 3-ply refer to and correctly describe the number of layers of saturated felt which cover the entire roof area.

When gravel roofs are applied on a concrete roof deck the standard practice is to coat the concrete with pitch and apply a complete coating of pitch over each layer of felt; when applied over a wooden roof deck, the first coating of pitch is applied over the second layer of felt and a coating of pitch provided with each succeeding layer of felt.

Gravel roofs are not generally adapted for roof inclines exceeding 2 in. fall to the foot horizontal, and an incline of from ¼ to ½ in. to the foot is better than an incline exceeding ½ in., for the reason that it makes more practical the use of the maximum permissible amount of pitch and gravel on the surface, and as the "built-up" method using saturated felt and pitch provides a surface that is watertight or will hold water, instead of being capable of simply shedding water, there are many practical reasons in favor of the roof deck having a minimum incline.

Pitch Coatings Must Be Uniform and Complete

In "built-up" roofs the fundamental principle involved is that the coatings of pitch shall be uniform and complete, for the reason that a coating of pitch that covers only 90 or 95 per cent of a given area is of no value in preventing leaks in the other 10 per cent or 5 per cent of the area, and the roof covering would, practically speaking, be serviceable for just as long a time if such an incomplete coating were omitted altogether. On an average 25 lb. of pitch is required for coating each 100 sq.ft. between the felt layers; and 75 lb. is required for the surface coating into which the surfacing of gravel is embedded.

Felts saturated with coal tar, and pitch obtained by the distillation of coal tar, are the materials which have been most generally and widely used for constructing "built-up" roofs, and are the materials on which the reputation of gravel roofs has been established. There are almost numberless instances where such roofs have given watertight service for upward of 20 years without repairs, and many instances of a life of 30 and even 40 years. A limited amount of open-minded investigation will produce proof of these statements. What has been done can be done again. Tarred felt and coal-tar pitch, at least the equal in quality of materials produced in former years, are available and contractors capable of skillful handling of these materials are also available to any one who will pay the price. Other saturants and other pitches from various sources are sometimes substituted for or offered as superior in quality to coal-tar pitch for use in gravel roofs. None has thus far shown any special merit or proven the equal of the materials originally used.

The gravel surface has three important functions: It permits the use of 75 lb. of pitch to the square (100 sq.ft.) on the surface by preventing the pitch from flowing to the low points of the roof—if gravel were not used a paint coat of pitch is all that would be prac-

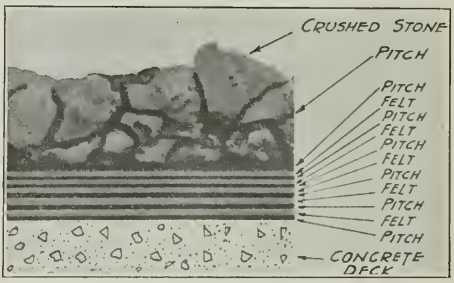


FIG. 1. GRAVEL ROOF APPLIED ON CONCRETE DECK. ILLUSTRATION ACTUAL SIZE

tical; it makes the roof fire-retardant (rated as Class "A" by the Underwriters' Laboratories); it protects the waterproofing material from wear and tear of the elements and more particularly from abuse, both necessary and unnecessary, to which most flat roofs are subjected. Crushed slag or any crushed rock may be used instead of gravel if it does not, like soft limestone, for example, disintegrate rapidly on exposure, or does not, as is the case with trap rock, crush into sharply angular particles. The standard practice is to require that the gravel or crushed stone be from ¼ to ⅝ in. in size, and while slight variation from this range may be permissible, there are practical reasons for complying as nearly as possible with the standard.

Prepared Roofings

Prepared bituminous roofings are of two general classes: (*a*) those composed of a single layer of felt of various thicknesses; (*b*) those composed of two or more layers of felt or other fabric cemented together with bitumen. The multiple layer prepared roofings are designated as 2-ply, 3-ply, etc., by counting the layers of felt or fabric that are stuck together, what-

ever their thickness or whether they happen to contribute to the element of waterproofing or not. The single layer roofings can be subdivided into two general classes: "smooth surfaced," i.e., those on which the bituminous coating forms the wearing surface, and "mineral surfaced," i.e., those having granular material in the form of crushed slate, feldspar, etc., or natural gravel or pebbles forming the wearing surface. The "smooth surfaced" roofings are generally made in three weights standardized at 35, 45 and 55 lb., and through an unfortunate trade practice known as 1-ply, 2-ply and 3-ply, respectively. The industry is endeavoring to correct this misnomer and recently voted unanimously in favor of designating the three weights as, "light," "medium" and "heavy." The "smooth surfaced" variety is sometimes referred to as "skin-coat" roofing, because the saturated felt is coated with bitumen, while the multiple layer roofings do not generally have a coated surface. They are also known as "rubber" roofing, because they feel something like and have an appearance similar to rubber. The term "rubber" has been used to such an extent as to have practically become generic, as applying to roofing composed of a single layer of felt saturated with bitumen and coated with bitumen without a surface of granular material.

"Rubber" Roofing

The "rubber" roofings of each weight are produced in all sorts of qualities. Each manufacturer has his own ideas regarding the maximum to which he is willing to go in producing a serviceable article, whatever the cost. Likewise, each has his own idea about the minimum for which he is willing to stand sponsor in the effort to meet price competition. Most manufacturers produce four or more varieties under different trade names or brands, the price range between the maximum and minimum being roughly as 10 to 6. All "rubber" roofings have a finely ground soapstone or talc brushed over the surface to prevent sticking in the roll. This gives the roofing a light colored appearance when unrolled which is often retained for a considerable period. In order to provide a different appearance for the different qualities manufacturers use powdered soapstone of different degrees of fineness and sometimes a very fine sand, and also endeavor to control the size of the corrugations in the coated surface or pass the roofing through smoothing rolls after coating the surface, to remove the corrugations altogether. There is no standard practice in this endeavor to have the different grades of roofing distinctive in appearance, each manufacturer adopting whatever practice seems best suited to his particular line.

Mineral surfaced roofings are generally made on the same base as is used for 2-ply "rubber" roofing, and when a mineral surface is applied the other side of the felt is usually left uncoated. Crushed slate, either red or green, has during recent years become the most popular mineral surface. Apparently, crushed slate has some inherent merit that is not present in other forms of granular material, the most plausible reason advanced being that slate crushes into less angular particles than feldspar, quartz or other stone, and more completely covers the bitumen into which it is embedded. Another reason for the popularity of the slate surface is the color, and as this is natural in the slate it does not fade. The standard weight of slate surfaced roofing is 80 to 85 lb. to the square.

Practically all prepared roofings are put up in rolls sufficient to cover 100 sq.ft. (known in the roofing trade as a square) allowing for whatever lap is recommended in the directions enclosed in the roll. A 2-in. lap is usually recommended, and in laying roofing with a 2-in. lap 108 sq.ft. of fabric is required to cover 100 sq.ft. of surface.

Felt Base Shingles

The use of crushed red or green slate as a surfacing material for prepared roofing and the cutting of that roofing into shingles were the first development in the felt base roofing industry toward providing a roof covering having any artistic merit, the shingles in particular giving relief to the objectionable flat effect and conforming to the popular idea of what a roof surface should be like, inherited by reason of use for generations of wooden shingles and slate. The serviceability of the material used in a single layer has long been established, and the popularity of slate surfaced asphalt shingles has caused them to fill a long felt want in almost every community where roofing with artistic merit and at the same time fire retardant and of moderate cost was desired. They are dependable for use on practically every structure the roof surface of which has an incline in excess of 4 in. to the foot.

Slate surfaced shingles are generally furnished in size 8 x 12⅔ in. laid 4 in. to the weather, thereby providing triple protection; or in strip form, four shingles to the strip, 10 in. wide laid 4 in. to the weather and providing double protection.

Prepared roofing and shingles are sold under trade mark brands. Most manufacturers have been wise enough to maintain the quality in the several brands they have established. As is the case with cigars, new

FIG. 2. ENLARGED CROSS-SECTION "RUBBER" ROOFING

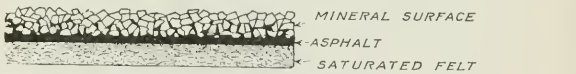


FIG. 3. ENLARGED CROSS-SECTION MINERAL SURFACED PREPARED ROOFING

FIG. 4. ENLAGED CROSS-SECTION MULTIPLE LAYER PREPARED ROOFING

brands of prepared roofing are coming out all of the time to replace old brands which are run out, and for about the same reasons.

Comparative Roofing Material Tests

It is with some misgiving that the following tests are offered as a guide in buying roofing, but they are simple and, therefore, available to practically every buyer at a minimum of trouble and expense. It should, however, be kept in mind that there is no united opinion in the industry as to the value attached to any one of the tests; that there are no agreed maxima or minima, and that one piece of roofing might be distinctly sub-

standard when compared with another, if judged by one of the tests, and yet be a much better article.

Therefore, if one test is to be made use of in judging the comparative value of a piece of roofing, most of the other tests should also be made, for the reason that thickness may be obtained by use of inert mineral filler; tensile strength obtained at the expense of pliability; pliability by the use of soft saturant or coating readily volatile, etc. The tests are useful only as a basis for comparison. A succession of tests will show uniformity, or the lack of it. Uniformity is at least indicative of care in manufacturing processes.

Thickness: This is readily determined by the use of a micrometer registering thousandths of an inch and having a face at least a half inch in diameter. Mineral surfacings other than soapstone should be carefully scraped off before measurement is taken.

Tensile Strength: Specimens should be cut lengthwise from the middle of the sheet 5 x 1¼ in. reduced to 1 in. wide for a distance of about 2 in. at the center. The ends of a specimen must be held in clamps which swing freely so as to avoid unfair tearing strain. Tests are usually made at a temperature of 77 deg. F. Ten breaking tests are averaged.

Absorption of Moistures: Tests should be started with pieces 18 in. square and due to freshly cut edges more readily absorbing water they should be trimmed 3 in. all around before re-weighing, making allowance for the reduced area when comparing weights. Immerse in soft water at 77 deg. F., for 100 hr., or suspend in atmosphere artificially saturated with moisture. Weight before and after tests indicates degree of thoroughness of saturation and waterproofing quality.

Pliability: Strips 1 in. wide cut lengthwise from center of sheet bent under water. Bend the sample around a series of cylinders ½, 1, 1½, 2 and 2½ cm. in diameter (approximately $\frac{3}{16}$ to 1 in.) in exactly two seconds time. The absence or presence of cracks on the surface, or deeper cracks when bent over the smaller size cylinders, furnish the comparison.

Volatility: Tests at high temperatures are of little value. Exposure of samples hung edgewise to dry heat of maximum summer temperature, and careful comparison of weight before and after will disclose fugitive solvents and tendency to become brittle. If comparison of same samples before and after drying show marked increase in tensile strength it suggests lack of permanent waterproofing quality.

Inert Mineral Filler: Remove all mineral surfacing material, record the net weight of sample, burn it completely and weigh the ash. Dry felt contains from 6 to 10 per cent, by weight, of ash, and the dry felt weighs approximately one-fourth as much as the finished roofing without mineral surfacing. More than 3 per cent, by weight, of ash recovered on burning sample of roofing indicates use of inert mineral filler, either in dry felt, saturant or coating.

Building Specifications

It is only fair to note that as a rule purchasing agents and architects make their drawings and specifications which relate to roof decks, roof faces, joinings, flashings and connections so incomplete, indefinite or general that the owner is dependent almost entirely upon the skill and good faith of the roofing contractor and his employees for serviceable roof protection. When an effort is made to draw a drum-tight specification the result is frequently an unworkable instruction. In the absence of competent and complete inspection a rigid specification serves only to eliminate the conscientious bidder and insure the presence on the job of adventurers, willing to take any chances.

In the purchase of roofing this condition of indefiniteness, when recognized at all, is offset by the guarantee. The guarantee is a form of abuse which has survived longer than 50 years from the early days of the industry when bitumen roofs were experiments offered to replace unsatisfactory metal roofs. No guarantee ever yet kept water out of a building. At its very best the guarantee merely secures repairs, after the roof has leaked, without direct charge. It never covers consequential damages to the interior of the building or its contents. The existence of the guarantee never serves to deter the irresponsible adventurers from taking chances. On the other hand, it frequently serves him as self-justification for producing a roof calculated to a nicety to just "get by." The architect or engineer who permits this does not serve his client faithfully.

It is impossible to cover fully within the limits of an article like this all of the problems which grow out of the endless combinations that may be produced from this assortment of bitumens, gums, solvents, thinners, fibers, fillers, weight-makers and adulterants. The mere mention of some of them causes the observer of ordinary intelligence accurately to visualize their probable value for roofing purposes, or the lack of utility which they represent in the hands of any so ignorant or unscrupulous as to use some of them. Aside from labor, fuel, equipment and plant supplies, probably 90 per cent of the industry represents the utilization of what is, or until within recent years was, commercial or domestic waste materials. This fact has been unfairly made the excuse for turning out roofing materials which are deficient in tensile strength, ductility, durability and weatherproofing qualities. Those are the requirements which measure the utility of roofing faces in terms of service to the ultimate consumer. Success in this business is in direct proportion to the delivery of such service.

General Conclusions

Other things being equal, bituminous roofs are serviceable in direct proportion to the quantity of bitumen uniformly contained in each square foot of the covering.

Felt, and mineral surface if used, must be ample in quantity to permanently hold waterproofing material.

Joinings, flashings and connections require for their construction real skill, based upon experience, otherwise they surely cause trouble, however good the roofing material may be.

In general coal tar pitch makes the most satisfactory flat roofs, while asphalt from various sources is more readily adaptable for steep roofs, but each must be properly combined with suitable felts.

Flat roofs should be flat, the more nearly level and providing some drainage the better; while steep roofs should be steep, not less than 4 in. fall to the foot. A fall of 5 to 6 in. to the foot is best in latitudes where there is ice and snow.

Roofing of relatively temporary nature is justifiable only on buildings known to be temporary, but during that predetermined temporary period it must be quite as tight as any other roof.

Recent Chemical and Metallurgical Patents

Canadian Patents

Extracting Iodine and Other Chemical Products From Seaweed by Dry Distillation.—Iodine or like products are extracted from seaweed by dry distillation in a closed retort. The gases are passed through a condenser and the uncondensed gases are passed through a metal salt which will absorb the volatile iodine and bromine. The residue of the retort is soaked with water and the dissolved salts are separated. (Canadian Patent No. 187,721, J. A. W. BREDENBERG.)

Refining of Volatile Metals.—The metal to be refined is fed in an electric-arc furnace through a liquid trap formed by said metal, so as to maintain a metal bath in the furnace bottom, the surface of the bath is exposed to heat from the arc and the metal vapors are removed and condensed. (Canadian Patent No. 187,864, S. HULDT.)

Alumina Purification.—The impure alumina resulting from the calcining of alunite and the leaching of the calcine is mixed in a finely divided condition with water to form a pulp, and the resulting pulp is subjected to a flotation operation with the addition of an agent promoting the flotation of the alumina, and thereby separating the alumina in the form of a froth from the impurities and recovering the alumina from the froth. (Canadian Patent No. 188,441, J. W. HORNSEY, assigned to the Minerals Products Corp. of New York, Jan. 28, 1919.)

White Gold, a Substitute for Platinium.—The process of manufacturing white gold consists of fusing fine gold, pure nickel and pure zinc and mixing them thoroughly while in fusion. The proportions of the components are: Gold 75 to 85 per cent, nickel 10 to 18 per cent, and zinc 2 to 9 per cent. (DAVIS BELAIS, Canadian Patent No. 188,628.)

English Patents

Distilling Zinc.—To obtain the maximum amount of zinc in zinc distilling processes, the zinc dust deposited in the condenser is subjected to a rubbing action and to compression by means of a screw mounted to rotate in the bottom of a condenser. The zinc dust is forced by the screw to the condenser outlet and into a receptacle of molten zinc. The amount of compression and the duration of the pressure may be adjusted by varying the pitch of the screw and the extent to which the screw enters the opening. (English Patent No. 120,549—1918. E. S. BERGLUND. Not yet accepted. Jan. 8, 1919.)

Production of Ammonium Sulphate and Alumina.—Clay, bauxite and other natural substance containing aluminium with iron and silica acid is treated with sulphuric acid to yield an impure solution of aluminium sulphate. The solution is treated with a reducing agent such as sulphurous acid or a sulphite to reduce ferric to ferrous sulphate, and is mixed while at 70 to 100 deg. C. with ammonium sulphate, allowed to settle at this temperature, and the decanted solution is cooled to separate crystals of ammonium alum. The crystals are decomposed by exposing them to ammonia, either gaseous or in solution, to yield ammonium sulphate and aluminium hydroxide, which may be heated to obtain alumina. (English Patent No. 120,550—1918. J. P. A. LARSON and W. D. BERGMAN, both of Stockholm, Sweden. Not yet accepted. Jan. 8, 1919.)

Platinized Asbestos as a Catalytic Agent.—Platinized asbestos for use as a catalyst is prepared by dissolving platinum in aqua regia, evaporating the solution to dryness, extracting the residue with hydrochloric acid, neutralizing the solution with soda, mixing it with a paste of asbestos and distilled water, and reducing at 60 deg. C. by formic acid. The product is finally washed, dried, carded and made into flakes. (English Patent No. 120,551—1918. E. FRABETTI, Rome, Italy. Not yet accepted. Jan. 8, 1919.)

Thorium Compounds.—Solutions containing thorium obtained, for instance, by dissolving in water the product of the action of sulphuric acid or monazite sand are treated with oxidizing agents such as potassium or sodium permanganate or hydrogen peroxide in the presence of acid. Hydrated thorium oxide or peroxide is precipitated and may be dissolved directly in nitric acid or other acid, and the resulting solution may be crystallized. The thorium nitrate may be purified by precipitation by the oxidizing agent first employed, or the solution may be treated with sodium carbonate in excess, which dissolves the thorium carbonate first produced. The solution is filtered and treated with caustic soda to precipitate thorium hydroxide, which is then dissolved in nitric acid. (J. V. and W. A. CLARKE, London, England. English Patent No. 120,748—1918. Jan. 15, 1919.)

Malleableizing Cast Iron.—Iron castings to be malleableized are heated in the presence of Mond blast-furnace, or like gas, containing carbon dioxide and hydrogen. Sufficient carbon monoxide is preferably present to prevent excessive decomposition of the carbon dioxide by the hydrogen. Sulphur and hydrocarbons are preferably removed from the gas before use. The temperature of treatment is 700 to 800 deg. C. for black-heart castings, and 800 to 950 deg. C. for white-heart castings. (English Patent No. 21,074—1918. F. PERRY and INDUSTRIAL INVENTIONS, LTD., Tipton Staffordshire, Eng., Jan. 29, 1919.)

Lead Arsenate. — Lead arsenate is produced by thoroughly mixing, preferably by rubbing or grinding, lead carbonate or white lead with arsenic acid in the presence of water. A concentrated solution of arsenic acid may be used, and water may be added at the end of the reaction to produce a paste of the desired consistency. (English Patent No. 121,101—1918. J. LYTLE, Dunbyon, Formby, Eng., Jan. 29, 1919.)

Preservative Coating of Metal Surface.—A preservative coating is formed on metallic articles by dipping the article into an oil, for example, a mixture of whale oil and mineral oil, draining and then heating to a temperature high enough to gasify the volatile constituents in an oven, which permits the escape of the lighter gases. A suitable oven is one having an outlet at the top, the aperture of which can be varied, and a suitable temperature is about 300 deg. C. (English Patent No. 121,150—1918. N. C. F. JENSEN, Southall, Middlesex, Eng., Jan. 29, 1919.)

Vom Baur Electric Furnace

By C. H. Vom Baur

VERY soon after electric furnaces in the iron and steel industry were placed in commercial operation in the United States, some eleven years ago, it became evident that one of the limits of their possibilities depended on the life of the refractories. All kinds and types of electric furnaces have to take care of this item much more than any open-hearth furnace. The experience of many electric furnace operators and designers has been along these lines. The simplest refractories of any arc furnace are those of the single phase, single electrode type, with a bottom electrode, when this has a round hearth and the carbon electrode at its center. (See Fig. 1).

It is evident that the heat at the inner contour of the side walls and of the slag line of this furnace is the same at any point thereof. Consequently when the side walls

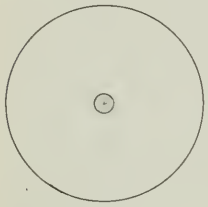


Fig. 1

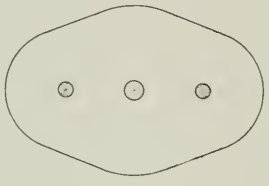


Fig. 2

burn away they do so equally. That is to say, there are no hot spots on any portion of the side walls or slag line, due to the heat of the arc, and manifestly no portions of the refractories need repairs when properly laid, prior to some other portion. As the single phase furnace of any but the smallest sizes is not popular with central station managers, it is seldom seen today in the newer installations, polyphase furnaces having almost exclusively taken their place.

At first, on account of the many advantages of the polyphase furnace, compared to the single phase, the refractory feature as above mentioned did not receive the attention it deserved until the appearance of the Vom Baur electric furnace, which has with its three electrodes, 3-phase 2-wire, the same good heat distribution as the simple single-phase furnace, as shown in Fig. 1. This good heat distribution in this furnace is accomplished by the combination of placing three electrodes in a straight line, and very nearly knowing the electrical heat, at least close enough for all practical purposes, which emanates from any of these electrodes after the bath is in the molten state, or nearly so. The contour of the inner refractories can easily be ascertained so as to give a curve to the refractories which is correct, so that the heat at the slag line, at the side walls and at the hearth banks is the same, thus assuring among others the equal burning away of all the refractories involved. Only very small allowances from the theoretical have to be made in order to accomplish this purpose. The shape as given to these furnaces is shown in Fig. 2.

Fig. 2 shows a well defined minor axis drawn through the middle electrode, and this shape is the natural result of the radiated heat reaching points on the minor axis from the three electrodes. Theoretically, the center electrode would have 41 per cent more heat than either of the end electrodes, but it is not possible to reach this condition practically and maintain the arcs at their best setting. The current at the central electrode is therefore diminished by several per cent and the extreme points in Fig. 2 are brought slightly together. Even so, the heat from the central arc is fully one-third more on an average than from either of the end arcs, and consequently in order to keep the refractories at their proper distances the metal bath has a larger surface than the furnace would have if each of the electrodes ever gave off an equal amount of heat. With basic operation the advantage is that the metal presents a greater slag area for the same tonnage. As the rate of refining depends not only on the chemical composition of the slag and the heat at the point of contact between the metal and the slag, but also on the amount of surface engaged between the slag and the metal, it follows that the rate of refining is quicker.

There is very little poking to be done when melting down cold scrap, as there are no hot or cold spots on the side walls or near the doors. The quick melting down with this furnace, as with all others, depends mostly on the amount of transformer capacity which the furnace has. However, as this furnace has an even heat distribution at the side wall refractories, it is more efficient than the other furnaces which lack this feature.

Special attention has been given to the doors, which have watercooled frames, fit very snugly, yet allowing

FIG. 3. DISCHARGE OF 6-TON FURANCE AT THE HERCULES STEEL CASTING CO. PLANT

for all expansion, and can be tightened after they are closed by giving two handles a few turns.

Structurally, the furnace is very strong, having a rounded and cone-shaped bottom connected with the upper shell, which is a series of curves. This sets on two rocker arms and the whole is tilted by means of connecting rods from suitable geared mechanism in such a way that when the furnace has reached its maximum tilting position, if the operating motor should continue to run for any reason, the furnace goes back to its normal position nevertheless. The tilting mechanism also allows the furnace to tilt slightly backward some 6 deg. and 7 deg., so that the slag can be taken off this door instead of from the spout. Both doors are used for charging.

The center of gravity of the furnace is low, as the heavy parts of the standards are no higher than is needed for the full travel of the arm holding the electrodes, and as these have an upward tilt the upright standards are still further shortened. For carrying the copper cables a much lighter structure is used, all of which can be seen from the photographic reproductions.

Either carbon or graphite electrodes can be used and changed quickly; either hand or automatic electrode control is furnished. The oval shape and turtle-back construction of the roof makes a very strong construction, standard brick being used throughout for the roof construction, excepting a few special electrode brick. The electrical connections are the simplest possible, being merely three sets of cables from the transformers to the electrodes, and no complication on the high tension side. Electrically the furnace conditions are satisfactory to the central station managers, the power factor being around 90 per cent and the phases not being distorted more than with other arc furnaces. After continued operation it has been observed that the furnace does not bulge at all, this being another indication of the even heat distribution as mentioned.

The furnace is equally well adapted for melting down miscellaneous steel scrap for castings on either acid or basic bottom, selected scrap for quality and tool steels, or for melting down cast iron borings, or the like, or for use with malleable iron. The furnace is made in sizes from ¼ ton up to 30-ton sizes and for any electrical condition. The first of these furnaces in this country of 6-ton size has been placed in operation at the works of the Hercules Steel Casting Co., Milwaukee, Wis. Others are being installed both here and abroad, and the patents for France, Belgium, Italy, Switzerland, and Spain have been disposed of to Le Flaive & Co. of St. Etienne, France.

Woolworth Bldg.,
New York, N. Y.

Personal

Mr. Oliver U. Bradley is U. S. oil and gas inspector for the Department of the Interior at Muskogee, Okla., with offices in the Federal Building.

Mr. W. J. Cotton, formerly chemical examiner for the United States Civil Service Commission, has joined the staff of the Color Investigation Laboratory of the Bureau of Chemistry, Washington, D. C.

Mr. Courtenay DeKalb recently sailed for Spain to investigate the metallurgical and mining resources of that country for the Department of Commerce.

Mr. J. H. Deppeler of the Metal & Thermit Corp. has been elected a director of the American Welding Society.

Mr. Henry B. Faber, head of the school of pyrotechnics, Columbia University, was recently tendered a dinner and presented with a loving cup by the staff of the school. Mr. Faber has also been appointed associate in the department of chemical engineering at Columbia University.

Lieut. Russel C. Gebert, recently released from the Ordnance Department of the Army, has been made chief metallurgist and superintendent of heat-treating at the Hammond Steel Co., Syracuse, N. Y.

Dr. Federico Giolitti is to be awarded the Bessemer medal of 1919 by the Iron and Steel Institute of Great Britain at its meeting on May 8.

Mr. Samuel M. Green, president of the Samuel M. Green Co., Inc., Springfield, Mass., has become a director of the Norwalk Iron Works, South Norwalk, Conn.

Prof. H. E. T. Haultain of the mining department of the University of Toronto is in charge of the Vocational Training Branch of the Department of Soldiers' Civil Re-establishment under Mr. W. E. Segsworth, a mining engineer of Toronto, who is in charge.

Capt. C. A. Jennings has received his discharge from the Construction Division, Utilities Branch, of the Army, and has returned to the technical staff of Wallace & Tiernan Co., Inc., to resume charge of the Chicago office. Captain Jennings' work in the Army covered the supervision, operation and maintenance of water purification and sewage treatment plants in various camps.

Mr. W. A. Maxwell, formerly superintendent of the open-hearth department of the Homestead Works, Carnegie Steel Co., has resigned to become assistant general superintendent of the Cambria Steel Co., Johnstown, Pa.

Dr. William C. Moore, for the past five and a half years research chemist for the Cleveland plant of the National Carbon Co., Inc., has resigned in order to take charge of the physical chemical research in the department of immunology in the school of public health and hygiene recently established by the Rockefeller Foundation at Johns Hopkins University, Baltimore, Md.

Prof. Albert Sauveur of Harvard University has returned to Cambridge, Mass., from France, where he had charge of the section of metallurgy in the technical division of the United States air service.

Mr. C. C. Wallace, formerly manager of loading of munitions section of the Stenotype Co., Indianapolis, Ind., is now director of development and service of the Powdered Coal Engineering & Equipment Co. of Chicago.

Capt. A. U. Wetherbee, who recently received his discharge from the Chemical Warfare Branch of the service and who was formerly chief engineer and assistant works manager of the Niagara Alkali Co., has accepted a position as chief engineer with the Powdered Coal Engineering & Equipment Co. of Chicago.

Current Market Reports

The Non-Ferrous Metal Market

Saturday, April 26.—The non-ferrous market has hitherto been uncertain but is expected to follow the conditions created by the iron and steel activity due to lowered prices.

Aluminium:—Conditions are unusually quiet, as aluminium has not declined. Ingots 98-99 per cent, 29-31c. lb. Sheets 18 gage and heavier, 42c. Powder, 0.70-1.40 lb.

Copper:—The market remains quiet with prices standing at 15¾ to 15½c.

Copper sheets, hot-rolled	lb.	$0 22½—	.....
Copper sheets, cold rolled	lb.	.23½—	.....
Copper bottoms	lb.	.30½—	.....
Copper rods	lb.	.19½—	.....
Copper wire	lb.	.17½—	$0.18
High brass wire and sheets	lb.	.18½—	.....
High brass rods	lb.	.17½—	.....
Low brass wire and sheets	lb.	.18½—	.....
Low brass rods	lb.	.21½—	.....
Brazed brass tubing	lb.	.29½—	.....
Brazed bronze tubing	lb.	.33½—	.....
Seamless copper tubing	lb.	.28 —	.....
Seamless bronze tubing	lb.	.29½—	.....
Seamless brass tubing	lb.	.30 —	.....
Bronze (gold) powder	lb.	1.00 —	.....

Antimony:—Wholesale lots are offered from 6¾ @ 7c. and jobbing at 7¼c. The market has a brighter outlook.

Lead:—Prices have declined to 4.75c. per lb. in East St. Louis and 4.975c. per lb. in New York. Sheet lead, 7¾ @ 8c. per lb.

Tin:—The 72½ price fixed by the committee continues and buyers are reluctant, knowing that a considerable decline will come eventually.

Zinc:—Future quotations at East St. Louis are rising: May, $122.50; June, $123.50; July, $124.50; August, $125, and September, $126 per ton. New York spot is $121.50. Zinc dust, 14c.; sheet zinc, 11c. per lb.

OTHER METALS

Bismuth	lb.	$3.20 —	$3.65
Cadmium	lb.	1.40 —	.....
Cobalt	lb.	2.50 —	3.50
Magnesium	lb.	1.75 —	2.10
Mercury	75 lb.	75.00 —	.....
Nickel	lb.	.40 —	.45
Tungsten	lb.	Nominal	
Iridium	oz.	175.00 —	.....
Palladium	oz.	115.00 —	120.00
Platinum	oz.	99.00 —	100.00
Silver	oz.	1.01⅛ —	.....

The Iron and Steel Market

By the middle of April it became generally recognized that the Industrial Board plan for handling the steel market had failed. The popular version was, of course, that the plan failed because the Railroad Administration refused to "co-operate." Scarcely any thought was given to a similar refusal on the part of the Navy Department. Sentiment was not lacking. The Railroad Administration is unpopular, while the Navy Department is an institution of which Americans are proud.

The steel trade was quick to accept as final the apparent failure of the Industrial Board to secure the results it had expected. The steel industry did not seek the Industrial Board for the purpose of suggesting that if a few dollars a ton stood in the way of Railroad Administration endorsement of the plan the barrier might perhaps be removed. For this ready adoption of the idea that the plan had failed there was another reason, which from its nature is not dilated upon, and that is the absolute refusal of the Department of Justice to endorse the plan. The department would not give approval, in advance, of a plan announced to operate for the remainder of the year when there was a possibility that matters might so shape themselves that it would in essence represent an agreement for the maintenance of prices. It was that feature of the whole arrangement that had appealed to the steel industry in the first place. Orders for a few hundred thousand tons of rails, with perhaps a few tens of thousands of freight cars and a few thousand locomotives, represented merely a detail. The important feature promised was that the sellers of steel could assure the public that there was no occasion to wait, that no lower prices could be expected at any time this year. Even at best, however, there was a weak spot in the argument, for the investor in a construction job would not weigh merely the respective advantages of building now or six months hence, but also the advantages respectively of building this year or next year, or even the year after.

The steel trade was as quick to assert that the Industrial Board plan was a failure and that an open market for steel products would follow as it was slow in taking any steps to establish an open market. That steel prices would eventually decline from the level established March 21 has been generally predicted or admitted, but the time of the decline has been altogether in doubt. The break may occur any day, or may be delayed until next June, possibly even longer.

Steel Organization Appears Intact

The organization of the steel trade appears to remain intact, this organization consisting merely in a mutual understanding that what is good for one is good for all and what is good for all is good for one. On account, however, of the very unequal distribution of old orders, upon which, rather than upon fresh bookings, the steel mills are chiefly operating, some producers may easily conclude that their best course lies in cutting prices even though a market decline would be disadvantageous to others. In the price maintenance operation of 1908 the circumstances were altogether different, as it was then contrived that all producers should operate at substantially the same rate. At the present time operating rates are widely divergent.

The philosophy of the steel trade is that inasmuch as light operation involves heavy overhead and therefore relatively high cost, prices should be maintained as well as the thing can be done, until it is reasonably certain that reducing prices will fill the mills, giving a lower production cost and at the same time enabling the market to start upon an advance. No matter what the price level may be, when mills begin to fall behind in deliveries advances begin. Given such a condition, it matters relatively little to what level prices may temporarily fall, as they can quickly recover, but if prices fall without full operation being produced the tendency is for them to decline farther. For instance, a mill operating at 65 per cent can well afford to take additional business at particularly low prices in order to raise the operating rate to 85 per cent, as the cost of production of the entire output will be reduced. Steel prices, therefore, will decline when producers feel there is large business to be secured. Thus far they have not displayed a hopeful frame of mind.

Steel mill operations, which averaged 87 per cent of capacity in January and 77 per cent in March, declined to a rate of not over about 60 per cent in the closing days of April. Even that is not an altogether bad rate, if maintained uniformly throughout the industry, but some small plants were closed entirely while some large independents operated at not over 45 per cent. Most of the Steel Corporation subsidiaries operated at 70 per cent or more, the Steel Corporation having apparently picked its orders, long ago, in anticipation of some such situation as this.

Pig Iron Independent of Steel, Marketwise

Marketwise, pig iron has shown its entire independence of steel. The merchant furnaces gave but lukewarm assent to the Industrial Board plan when first proposed, and when the Industrial Board prices were announced March 21 they expressed their disapproval of the price structure very plainly, as they felt that steel was reduced altogether too little in proportion to pig iron. The pig-iron market had been an open one until the Government took charge as a war-time measure, and the furnaces had no objection to a return to that condition. Accordingly they stated to all interested that there would be an open market in pig iron. It was not that the furnaces desired prices to decline, but that they desired, through actual experiment, to ascertain where prices would go if left to themselves. The individual furnace could then determine whether or not to blow out, awaiting either higher prices or lower production cost or both. The experiment, however, has been rather unsatisfactory thus far, the reaction being very sluggish. In other words, while merchant furnaces are willing to cut prices few opportunities, by way of inquiries of any size developing, have been afforded, and in most districts the March 21 prices still obtain, nominally at least.

The Chemical Market

New York, April 25.

Coal-Tar Products: — Considerable improvement is noted in this situation, particularly in the way of heavy crudes. A number of the items have been in demand in a liberal way for the past month or more, and it is not exaggerating to state that more material has been sold during the past month or six weeks than for six months previous to this time. Benzol in particular has felt the effects of the increased demand. As a result prices have advanced from 10 to 15 per cent during the past two months. It is also encouraging to producers to note that buyers are contracting over longer periods, as well as buying in large quantities. The other crudes are also more active and prices in most cases have advanced. Naphthalene, however, is an exception; although material is moving much more freely, prices are easy.

Phenol:—The demand has improved and large quantities

are moving. While prices are slightly firmer and higher, they are not greatly changed. This is due to the fact that large quantities are available.

Benzol:—A decided improvement is noted. Buyers are closing for large quantities both spot and contract. During the past week prospective buyers have experienced difficulty in securing spot material, which is so unusual that it is a matter of discussion in the trade.

Naphthalene: — Buyers are closing for large quantities. Although the demand is hardly as brisk as it was when the industry was booming, there is some improvement. The fact that large quantities of material are available tends to keep prices at low levels.

Toluol: — The volume of business closed is quite heavy in the aggregate, but the demand is mostly for moderate quantities. Tank car lots are not moving to any extent, but nevertheless prices are stiffer.

Aniline Oil:—While there appeared to be a firmer undertone to this market for a time, prices were lowered in most instances by second hands shading producers' prices.

Benzaldehyde:—The production is heavier than formerly, with the demand only fair, and prices are easier as a result.

Paramidophenol:—The production has increased of late, but the demand is quite regular and prices are unchanged.

Orthotoluidine:—Buyers are operating on a conservative basis, the production has increased, and prices while quotably unchanged are shadable in most instances.

H Acid: — Most of the business passing is for small quantities, material is plentiful and prices are lower.

Phthalic Anhydride:—There are some large factors competing in this situation and prices have been slashed in some instances in an endeavor to line up business.

Xylol: — The demand is only routine and prices, while quotably unchanged, are little less than nominal under the circumstances.

Paratoluidine: — Consumers are limiting their purchases to small quantities, with prices somewhat lower.

HEAVY CHEMICALS: — While there has been no resumption of important activities in the heavy chemical market, the past few weeks have shown more interest from buyers and producers are expecting a resumption of activities in the near future. A better inquiry for export material was noted which resulted in some improvement in trading in general in this direction and handlers of this business state the outlook for an increasing business is promising. The large tonnage used by the Government for the shipping of food supplies is easing up from week to week and the matter of space is in consequence more encouraging. Local trading is still confined to small-lot transactions, but consumers' stocks of many of the items seem to have become depleted and a slight improvement on the whole is noted.

Soda Ash:—Although there has been nothing in the way of any important trading reported, that is for material over the balance of the year, consumers appear more frequently in the market but are still confining their purchasing to immediate needs; however, this activity seems sufficient to keep the market for bag material firm. Bags from the warehouse were offered by second hands at from $1.55 to $1.60 while barrels were available at $1.70 to $1.75. No movement was noted in any direction, for double bags which were held at 2c. Middle West, with prices on a parity on the Pacific coast.

Caustic Soda:—The market for this material continues in a very weak position with the resale operators in control of the situation. An effort on the part of manufacturers to meet this condition has resulted in price declines among second hands and offerings were made as low as $2.50 ex-store, with other directions holding at $2.60 to $2.65. Manufacturers toward the latter part of the week were quoting $2.80 f.a.s. and intimated on a firm bid this price might be shaded.

Bleaching Powder:—Trading, for the most part, is direct, but the lack of demand has again had its effect on the market with manufacturers offering large export drums at 2c. f.a.s., while domestic drums were quoted at $1.40 to $1.50 works.

Chlorate of Potash: — There has been a fairly steady business passing for this commodity for export purposes, but the present rate of absorbing material is having no effect on stocks; however, trading is of sufficient volume to take the slack off the market. Prices for the domestic product are firmly maintained at 35c. to 36c. while the Japanese variety is offered at 29c. and 30c.

Sodium Sulphide: — A better demand was noted during the past week for this material and several important sales were reported which resulted in a firming up of the situation. The 60-62 fusel is now held in most instances at 4½c. with the 30-32 crystals being quoted at $1.90 to $2.

Sodium Formate:—Comparatively little is heard of this item in the general market; however, producers report a steady business passing, particularly for the crude material, which is subject to a fair demand. This item is held at from 25c. to 28c. according to quantity, with the crystals held at 35c., although some business has been closed below this figure.

Calcium Carbide:—No new developments have set in to indicate any firming up in this market, with sales noted at below 5c. However 5¼c. to 5½c. is generally asked for material crated for export.

Bichromate of Soda:—The lack of demand is having its effect in this market, with prices steadily declining for resale material. Manufacturers, however, are striving to hold the market at a level of about 10c. ex-store, but resale offerings were made at from 9c. to 9½c.

Bichromate of Potash: — While there has been no resumption of any important activities for this material, there seems to be sufficient business passing to keep the spot situation well sold up. Prices are quotably unchanged at from 34c. to 35c. f.a.s.

Cream of Tartar:—While the item has been neglected for quite a period, a fair volume of export trading has developed during the past week, which resulted in an advance in prices, from 55c. to 75c., with some now holding as high as 59c.

Potash Chrome Alum:—Available supplies of this product are only in limited quantities and in scattered lots. Spot material is generally held at from 19c. to 20c., while that for shipment about the middle of May is held at 18½c.

Chicago, April 25.

Conditions in the chemical market in Chicago continue very unsatisfactory in that quotations on the entire line of heavy chemicals and coal tar products mean very little. Large stocks on hand and a production in excess of sales have produced a condition whereby a buyer with cash can make purchases below the market and in many cases below actual cost of production. An example is caustic soda, on which the mill cost is $2.50 and market quotation $3.25. Cash buyers would have no difficulty in securing carload lots at $2.40. Carbolic acid can be had by merely paying for the container. These items are, of course, of exceptional weakness.

Consistently falling markets of the past few weeks have confirmed regular consumers in hand-to-mouth habits. Concerns normally anticipating in their purchases thirty days are now content to secure a week's supply, saying that the less they buy the more money they save, as next week they are sure to get lower prices.

Indications are, however, that this condition is nearing an end. Mercury has recently advanced and vegetable oils all show a tendency to be firmer in price; some items of this line are actually up ¼ to ½c. Soya bean oil, particularly, is in good demand. The announced policy of the Government to dispose of additional chemical stores in such manner as to least disturb the market is having a good effect.

FLOTATION OILS.—Prices are firm and sales very satisfactory. The annual spring clean-up, which was almost neglected last year on account of the war, has tended to strengthen the turpentine market, all other items in the line being affected to a certain degree.

NAVAL STORES.—Naval stores have been rather uncertain for some time, but with a gradual let-up of labor shortage in the producing fields and a continuance of consumption, conditions are very satisfactory. Sales for April are ranging 60 per cent in excess of those for last month. The market can be said to have certain indications of a downward tendency, or rather of an "evening up" tendency, with no great reductions to be expected.

Imports and Exports

The Department of Commerce reports the following imports and exports for February, 1919:

IMPORTS (TOTALS) AND EXPORTS (BY COUNTRIES) OF GLYCERINE

Imports

Lb.	Value
10,936	$4,657

Exports

Countries	Lb.	Value	Countries	Lb.	Value
Norway	112,000	$20,160	Argentina	212	$119
Portugal	50	35	Bolivia	215	62
England	182	92	Brazil	2,250	1,472
Bermuda	29	15	Chile	12,492	6,739
Canada	1,290	315	Colombia	1,579	822
Costa Rica	150	32	Ecuador	1,400	334
Guatemala	1,566	807	British Guiana	350	220
Honduras	32	13	Peru	4,856	3,035
Nicaragua	557	297	Uruguay	50	30
Panama	209	54	Venezuela	1,235	639
Salvador	20	15	China	17,975	4,707
Mexico	7,737	2,725	British India	13,200	4,600
Newfoundland	25	15	Straits Settlements	6,750	4,151
Trinidad	490	152	Hongkong	14,500	4,930
Cuba	24,256	8,414	Japan	109,105	37,821
Dutch West Indies	50	27	Philippine Islands	50	16
French West Indies	50	30			
Dominican Republic	45	45	Total	335,137	$102,984

EXPORTS OF CAUSTIC SODA AND SODA ASH, BY COUNTRIES

Countries	Caustic Soda Lb.	Caustic Soda Value	Soda Ash Lb.	Soda Ash Value
Denmark	100,320	$7,000	1,807,639	$45,910
Greece	80,500	3,220	.....	.....
Norway	156,860	7,456	.....	.....
Serbia	22,400	1,100	.....	.....
Spain	2	2	.....	.....
Sweden	165,640	8,428	1,402,760	49,157
British Honduras	.....	.....	20	1
Canada	742,048	34,805	1,390,497	27,848
Costa Rica	9,120	547	300	14
Guatemala	735	42	3,500	140
Honduras	17,040	758	1,296	89
Nicaragua	31,359	1,644	1,500	49
Panama	8,100	413	5,600	168
Salvador	2,532	157	500	21
Mexico	976,290	49,223	721,925	20,127
Newfoundland	50	5	.....	.....
Barbados	23,200	1,384	.....	.....
Trinidad	1,500	90	.....	.....
Cuba	252,117	8,496	430,177	6,264
Dutch West Indies	.....	.....	2,000	62
Dom. Republic	25,600	1,266	12,000	430
Argentina	1,060,601	65,010	.....	.....
Bolivia	22,400	1,000	2,800	110
Brazil	1,589,309	107,841	1,265,263	52,858
Chile	144,023	8,189	.....	.....
Colombia	102,096	8,624	33,419	1,335
Ecuador	4,620	207	.....	.....
Peru	509,624	22,772	86,100	3,675
Uruguay	638,300	31,704	56,000	744
Venezuela	38,605	1,891	3,000	90
China	4,114,100	209,479	261,212	8,772
British India	502,265	22,801	.....	.....
Straits Settlements	60,200	3,141	1,200	36
Dutch East Indies	1,200	66	44,000	1,800
Hongkong	489,006	23,452	.....	.....
Japan	910,983	47,665	3,764,070	148,294
Siam	41,100	2,445	.....	.....
Australia	373,442	22,594	330,312	16,215
New Zealand	539,010	33,025	1,960	98
Other British Oceania	3,650	310	.....	.....
Philippine Islands	659,475	27,137	.....	.....
British West Africa	56	3	.....	.....
Total	14,422,675	$765,394	11,049,040	$384,906

IMPORTS AND EXPORTS OF COPPER (TOTALS ONLY)

Imports

	Tons	Lb.	Value
Copper ore	19,149	5,071,159	$1,030,541
Copper concentrates	14,625	3,777,599	852,901
Copper, matte and regulus	4,310	4,975,442	1,100,143
Copper, unrefined	.....	33,369,626	7,754,203
Copper, refined	.....	202,375	50,594
Copper, old, scrap, etc	.....	512,866	83,030
Copper composition metal	.....	3,701	611

Exports

	Tons	Lb.	Value
Copper ore	30	4,200	$600
Copper concentrates, matte, etc	.....	.....	.....
Copper, unrefined	.....	108	52
Copper, refined	.....	30,454,013	7,625,443
Copper, composition metal	.....	79,645	22,016
Copper, old and scrap	.....	.....	.....
Copper, pipes and tubes	.....	490,979	206,772
Copper, plates and sheets	.....	3,812,266	1,084,758
Copper wire, except insulated	.....	5,914,617	1,819,806
Copper, a. o. manufactures	.....	.....	344,901

U. S. IMPORTS OF TIN BARS, BLOCKS, PIGS, ETC., BY COUNTRIES AND DISTRICTS—TOTAL IMPORTS OF TIN ORE

Countries	Lb.	Value
England	56,000	$43,377
Straits Settlements	6,092,721	3,990,533
Hongkong	56,056	36,338
Australia	67,200	47,784
Total	6,271,977	$4,118,032

Districts	Lb.	Value
Massachusetts	168,085	$127,493
New York	291,629	209,025
Pittsburgh	56,000	44,893
San Francisco	414,721	321,046
Oregon	56,400	36,490
Washington	4,784,544	3,042,120
Chicago	444,542	300,627
St. Louis	56,056	36,338
Total	6,271,977	$4,118,032

	Tons	Value
Total imports of tin ore	1,451	$884,411

IMPORTS AND EXPORTS OF PLATINUM, IRIDIUM, ETC., BY COUNTRIES

Imports

Countries	Platinum Ore Oz. Troy	Platinum Ore Value	Platinum Ingots, Etc. Oz. Troy	Platinum Ingots, Etc. Value
France	550	$68,668	..	.....
England	114	13,838	..	.....
Canada	26	3,165	55	$5,075
Cuba	8	827	..	.....
Colombia	2,535	196,732	..	.....
Venezuela	10	1,053	..	.....
Japan	80	6,979	..	.....
Russia in Asia	400	35,000	..	.....
New Zealand	2	206	..	.....
British South Africa	17	1,533	..	.....
Total	3,742	$328,001	55	$5,075

Iridium

	Oz. Troy	Value
England	1,355	$142,103
Canada	5	425
Australia	99	13,585
Total	1,459	$156,113

Exports

Countries	—Unmanufactured— Oz. Troy	—Unmanufactured— Value	Manufactured Value
Norway	....	....	$150
Canada	....	....	576
Chile	....	....	51
Peru	....	....	365
Total	....	....	1,142

U. S. IMPORTS OF LEAD AND ZINC, BY COUNTRIES, AND EXPORTS (TOTALS ONLY)

Imports

Articles and Countries	Gross Weight, Tons	Contents, Lb.	Value
Lead ore:			
Canada	352	329,802	$17,373
Panama	1	166	9
Mexico	2,203	170,950	7,710
Peru	12	19,093	940
Total	2,568	520,011	$26,032
Lead bullion and base bullion:			
Mexico	13,682,443	13,226,678	$594,812
Lead pigs, bars, etc.:			
Canada	.....	13,746	189
Guatemala	.....	7,009	421
Zinc ore, etc.:			
Canada	623	430,166	9,961
Mexico	5,519	4,197,697	73,518
Zinc blocks, etc.:			
Canada	.....	18	2
Zinc dust:			

Foreign Exports (Totals)

Lead ore	.....	.....	.....
Lead bullion	.....	.....	.....
Lead pigs and bars	.....	259,051	41,317
Zinc ore	.....	.....	.....
Zinc dust	.....	.....	.....

Domestic Exports (Totals)

Lead pigs—domestic ore	.....	5,454,105	435,876
Lead pigs—foreign ore	.....	8,260,586	498,4 2
Zinc spelter—domestic ore	.....	17,372,468	2,419,168
Zinc spelter—foreign ore	.....	4,259,622	382,681
Zinc in sheets	.....	9,320,666	1,159,536

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET APRIL 8, 1919

Acetic anhydride	lb.	.65	—	70
Actone	lb.	.15½	—	16
Acid, acetic, 28 per cent	cwt.	3 00	—	3 25
Acetic, 56 per cent	cwt.	6 00	—	6 50
Acetic, glacial, 99½ per cent, carboys	cwt.	13 00	—	14 00
Boric, crystals	lb.	.13½	—	15
Boric, powder			—	
Hydrochloric, tech. 20 deg.	cwt.	2 50	—	3.00
Hydrofluoric, 52 deg.	lb.	.08	—	.08½
Lactic, 44 per cent. tech.	lb.	.12½	—	.13
Lactic, 22 per cent. tech.	lb.	.05½	—	.06
Molybdic, C. P.	lb.	6.90	—	7 40
Nitric, 40 deg.	lb.	.06	—	07
Nitric, 42 deg.	lb.	.07½	—	08
Oxalic, crystals	lb.	.26	—	.28
Phosphoric, Ortho, 50 per cent. solution	lb.	.07½	—	.10
Picric	lb.	.50	—	.60
Pyrogallic, resublimed	lb.	2.70	—	3.20
Sulphuric, 60 deg tank cars	ton	12 00	—	13.00
Sulphuric, 60 deg. drums	ton	17.00	—	.....
Sulphuric, 60 deg. carboys	ton	20.00	—	.....
Sulphuric, 66 deg. tank cars	ton	17.00	—	20 00
Sulphuric, 66 deg. drums	ton	21.00	—	.....
Sulphuric, 66 deg., carboys	ton	25.00	—	
Sulphuric, fuming, 20 per cent. (oleum) tank cars	ton	22 00	—	25 00
Sulphuric, fuming, 20 per cent. (oleum) drums	ton	25.00	—	.....
Sulphuric, fuming, 20 per cent. (oleum) carboys	ton	30.00	—	.....
Tannic, U. S. P.	lb.	1 40	—	1.50
Tannic, (tech.)	lb.	.60	—	.....
Tartaric, crystals	lb.	.88	—	.89
Tungstic, per lb. of WO_3	lb.	1 60	—	1 75
Alcohol, Amyl	gal.	4 85	—	4 90
Alcohol, Methyl	gal.	1 28	—	1.30
Alum, ammonia lump	lb.	.04½	—	.05½
Alum, potash lump	lb.	.18½	—	.19
Alum, chrome lump	lb.	.17½	—	.18
Aluminium sulphate, commercial	lb.	.01½	—	.02½
Aluminium sulphate, iron free	lb.	.02½	—	.03½
Aqua ammonia, 26 deg., carboys	lb.	.06½	—	.09
Ammonia, anhydrous	lb.	.30	—	.35
Ammonium carbonate, powder	lb.	.13½	—	
Ammonium chloride, granular (white) sal ammoniac	lb.	.12	—	.13
Ammonium chloride, granular (gray) sal ammoniac	lb.	.14	—	.16
Ammonium nitrate		.16	—	.17
Ammonium sulphate	lb.	04 90	—	04 95
Amyl acetate	gal.	3 50	—	3 75
Arsenic, oxide, lumps	lb.	.09	—	.09½
Arsenic, sulphate, powdered	lb.	.30	—	.32
Barium chloride	ton	70 00	—	80 00
Barium dioxide (peroxide)	lb.	.22	—	
Barium nitrate	lb.	.10	—	.11
Barium sulphate (precip.) (blanc fixe)	lb.	.03½	—	.04
Bleaching powder, (see calcium hypochlorite)			—	
Blue Vitriol (see copper sulphate)	lb.	.08	—	.....
Borax, (see sodium borate)			—	.....
Brimstone, (see sulphur, roll)			—	.....
Bromine	lb.	.55	—	.60
Calcium acetate	lb.	.04	—	.05
Calcium carbide	lb.	.05½	—	.06
Calcium chloride, fused, lump	ton	19 00	—	21 00
Calcium chloride, granulated	lb.	.02½	—	
Calcium hypochlorite, (bleaching powder)	cwt.	1 40	—	2 00
Calcium phosphate-monobasic	lb.	.22	—	23
Calcium peroxide	lb.	1.50	—	1 70
Calcium sulphate, precipitate	lb.	.09	—	.09½
Carbon bisulphide	lb.	.07	—	.08
Carbon tetrachloride, drums	lb.	.14	—	.15
Carbonyl chloride (phosgene)	lb.	.75	—	1 00
Caustic potash, (see potassium hydroxide)	lb.	.42	—	.....
Caustic soda, (see sodium hydroxide)			—	.....
Chlorine, gas, liquid-cylinders, (100 lb.)	lb.	.08	—	.10
Cobalt oxide	lb.	1 60	—	1.65
Copperas (see iron sulphate)			—	.....
Copper carbonate, green precipitate	lb.	.28	—	.31
Copper cyanide	lb.	.65	—	.70
Copper sulphate, crystals	lb.	.07	—	.07½
Cream of tartar, (see potassium bitartrate)	lb.	.58	—	.59
Epsom salt, (see magnesium sulphate)			—	.....
Formaldehyde, 40 per cent	lb.	.22	—	.22½
Glauber's salt (see sodium sulphate)			—	.....
Glycerine	lb.	.16½	—	.17
Iodine, resublimed	lb.	4 25	—	4 30
Iron oxide, red	lb.	.06	—	.08
Iron sulphate (copperas)	lb.	.01½	—	.02½
Lead acetate, normal	lb.	.12½	—	.14
Lead arsenate (paste)	lb.	.15	—	.18
Lead nitrate, cyrstals	lb.	.85	—	.86
Litharge	lb.	.09½	—	.10½
Lithium carbonate	lb.	1 50	—	
Magnesium carbonate, technical	lb.	.15	—	.16
Magnesium, sulphate	100 lb.	2.25	—	2.35
Nickel salt, double	lb.	.14	—	.13
Nickel salt, single	lb.	.16	—	.15
Phosgene (see carbonyl chloride)			—	.....
Phosphorus, red	lb.	.75	—	.80
Phosphorus, yellow	lb.	.35	—	.40
Potassium bichromate	lb.	.34	—	.35
Potassium, bitartrate, (cream of Tartar)	lb.	.58	—	.59
Potassium bromide, granular	lb.	1.25	—	1.26
Potassium carbonate, U. S. P.	lb.	.17	—	.18
Potassium carbonate, crude	lb.	.14	—	.....
Potassium chlorate, crystals	lb.	.35	—	.40
Potassium cyanide, 98-99 per cent	lb.	Nominal		
Potassium, hydroxide, (caustic potash)	lb.	.42	—	.45
Potassium iodide	lb.	3 50	—	3 55
Potassium nitrate	lb.	.20	—	.22½
Potassium permanganate	lb.	.60	—	.75
Potassium prussiate, red	lb.	.85	—	.95
Potassium prussiate, yellow	lb.	.45	—	.55
Potassium sulphate	ton	Nominal		
Rochelle salts (see sodium potas. tartrate)			—	.....
Salammoniac, (see ammonium chloride)	lb.	.14	—	.16
Sal soda (see sodium carbonate)			—	.....
Salt cake (see sodium bisulphate)			—	.....
Silver cyanide	oz.			
Silver nitrate	oz.	.63½	—	.65½
Soda ash, light	100 lb.	1 50	—	1 55
Soda ash, dense	100 lb.	2.45	—	3.00
Sodium acetate	lb.	.07	—	.07½
Sodium bicarbonate	100 lb.	2 35	—	2 50
Sodium bichromate	lb.	.09	—	10
Sodium bisulphate, (salt cake)	ton	12 00	—	14 00
Sodium, bisulphite	lb.	05	—	.07
Sodium, borate, (borax)	lb.	.07½	—	.07¾
Sodium, carbonate (sal soda)	100 lb.	1.60	—	2.00
Sodium chlorate	lb.	16	—	.18
Sodium cyanide	lb.	.30	—	.31
Sodium fluoride	lb.	14	—	.15
Sodium hydroxide, (caustic soda)	100 lb.	2.50	—	2.65
Sodium molybdate	lb.	2.50	—	.....
Sodium nitrate	100 lb.	4.07½	—	.....
Sodium nitrite	lb.	.13	—	.14
Sodium peroxide, powdered	lb.	.25	—	.30
Sodium phosphate, dibasic	lb.	.03¾	—	.03¾
Sodium potassium tartrate (rochelle salts)	lb.	.43	—	.43½
Sodium prussiate, yellow	lb.	.18	—	.22½
Sodium silicate, solution (40 deg.)	lb.	.02½-.03	—	.04½-.05
Sodium silicate, solution, (60 deg.)	lb.	.03¾	—	.04¼
Sodium sulphate, crystals, (Glauber's salts)	lb.	.01½	—	.02
Sodium sulphide, crystal, 60-62 per cent, (cone)	lb.	.04½	—	.05
Sodium sulphite, crystals	lb.	.05¾	—	.06½
Strontium nitrate, crystals	lb.	.25	—	.30
Sulphur chloride	lb.	.07½	—	09
Sulphur, crude	ton	35.00	—	37 50
Sulphur dioxide, liquid, cylinders	lb.	.10	—	.12
Sulphur, (sublimed), flowers	100 lb.	3.05	—	3.15
Sulphur, roll, (brimstone)	100 lb.	2.70	—	3.10
Tin bichloride, (stannous)	lb.	.22½	—	.25
Tin oxide	lb.	.63	—	.66
Zinc carbonate, precipitate	lb.	.18	—	.20
Zinc chloride, gran	lb.	.13½	—	.14
Zinc cyanide	lb.	.49	—	.50
Zinc dust	lb.	.12	—	.13
Zinc oxide, dry American	lb.	.09	—	.11½
Zinc sulphate	lb.	.03¾	—	.04

Coal Tar Products—Intermediates, etc.

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	1.00	—	1.10
Alpha naphthol, refined	lb.	1 50	—	1 25
Alpha naphthylamine	lb.	.40	—	45
Aniline oil, drums extra	lb.	.22	—	24
Aniline salts	lb.	.32	—	.34
Anhtracene, 80% in drums (100 lb.)	lb.	$0.50	—	$.75
Benzaldehyde (f.f.c.)	lb.	1 30	—	1.50
Benzidine, base	lb.	1.00	—	1 15
Benzidine, sulphate	lb.	95	—	1 00
Benzoic acid, U. S. P.	lb.	1 00	—	1 25
Benzoate of soda, U. S. P.	lb.	1.00	—	1 25
Benzol, pure, water-white, in drums (100 lb.)	gal.	.22	—	.27
Benzol, 90%, in drums (100 lb.)	gal.	.22	—	.27
Benzyl chloride, 95-97%	lb.	35	—	38
Beta naphthol benzoate	lb.	5 50	—	6 00
Beta naphthol, sublimed	lb.	65	—	.....
Beta naphthylamine, sublimed	lb.	2.25	—	2 35
Cresol, U. S. P., in drums (100 lb.)	lb.	.18	—	.....
Ortho-cresol, in drums (100 lb.)	lb.	.23	—	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	.90	—	.95
Cresylic acid, 95-97%, dark, in drums	gal.	.85	—	.90
Cresylic acid, 50%, first quality, drums	gal.	.60	—	.....
Dichlorbenzol	lb.	15	—	20
Diethylaniline	lb.	2 25	—	2 75
Dinitrobenzol	lb.	.28	—	33
Dinitrochlorbenzol	lb.	.28	—	30
Dinitronaphthaline	lb.	.45	—	.55
Dinitrotoluol	lb.	40	—	50
Dinitrophenol	lb.	.32	—	34
Dimethylaniline	lb.	55	—	.60
Dip oil, 25% tar acids, car lots, in drums	gal.	.38	—	.....
Diphenylamine	lb.	70	—	75
H-acid	lb.	2 15	—	2 15
Metaphenylenediamine	lb.	1 55	—	1 75
Monochlorbenzol	lb.	.12	—	.14
Naphthalene, flake	lb.	.07	—	.08
Naphthalene, balls	lb.	10½	—	11½
Naphthionic acid, crude	lb.	1 20	—	1.30
Naphthalene, crushed in bbls. (250 lb.)	lb.	.07	—	.08
Naphthylamin-di-sulphonic acid	lb.	1.00	—	1.10
Nitro naphthaline	lb.	.40	—	.45
Nitro toluol	lb.	40	—	45
Ortho-amidophenol	lb.	6 00	—	7.00
Ortho-dichlor-benzol	lb.	.15	—	.20
Ortho-toluidine	lb.	40	—	45
Ortho-nitro-toluol	lb.	40	—	45
Para-amidophenol, base	lb.	3 25	—	3 65
Para-amidophenol, H. C. l.	lb.	3 25	—	3 75
Para-dichlor-benzol	lb.	15	—	20
Paranitraniline	lb.	1 15	—	1 25
Para-nitro-toluol	lb.	1.50	—	1 60
Paraphenylenediamine	lb.	3 15	—	3 25
Para toluidine	lb.	1 50	—	1 70
Phthalic acid anhydride	lb.	2 50	—	3 00
Phenol, U. S. P. drums (dest.), (240 lb.)	lb.	.08	—	10
Pyridine	gal.	$2.50	—	.....
Resorcin, technical	lb.	4 25	—	45
Resorcin, pure	lb.	6 75	—	7 00
Salicylic acid, U. S. P	lb.	30	—	35
Salol	lb.	.75	—	85
Solvent naphtha, water white, in drums, 100 gal.	gal.	.20	—	.25
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.18	—	.20
Sulphanilic acid, crude	lb.	.25	—	.30
Toluidine	lb.	2 15	—	2 25
Toluidine-mixture	lb.	.70	—	75
Toluol, in tank cars	gal.	.22	—	.24
Toluol, in drums	gal.	.25	—	.27
Xylol, pure, in drums	gal.	.37	—	.45
Xylol, pure, in tank cars	gal.	.35	—	.....
Xylol, commercial, in drums, 100 gal.	gal.	.32	—	.40
Xylol, commercial, in tank cars	gal.	.30	—	.....

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	.36	—	.39
Beeswax, refined, yellow	lb.	.42	—	.45
Beeswax, white pure	lb.	.62	—	.65
Carnauba, No. 1	lb.	.78	—	.80

Carnauba, No. 2, regular	lb.	.65 —	.70
Carnauba, No. 2, North Country	lb.	.50 —	.53
Carnauba, No. 3, North Country	lb.	.40 —	.43
Ceresin, yellow	lb.	.15 —	.18
Ceresin, white	lb.	.16 —	.19
Japan	lb.	.14 —	.15
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.07 —	.08½
Paraffine waxes, crude scale, 117-119 m.p.	lb.	.08 —	.08½
Paraffine waxes, crude scale, 124-126 m.p.	lb.	.08 —	.08½
Paraffine waxes, refined, 118-120 m.p.	lb.	.09½ —	.10
Paraffine waxes, refined, 123-125 m.p.	lb.	.10 —	.10½
Paraffine waxes, refined, 128-130 m.p.	lb.	.11 —	.....
Paraffine waxes, refined, 130-132 m.p.	lb.	.11½ —	.11½
Paraffine waxes, refined, 133-135 m.p.	lb.	.11½ —	.12
Paraffine waxes, refined, 135-137 m.p.	lb.	.12½ —	.13
Stearic acid, single pressed	lb.	.17 —	.18
Stearic acid, double pressed	lb.	.18 —	.19
Stearic acid, triple pressed	lb.	.20 —	.22
Spermaceti	lb.	.30 —	.32

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lbs.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.		$0.68
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.		.45
Pine tar oil, ref., sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.		.33
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.		.58
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.		.38
Turpentine, crude, sp. gr., 0.900-0.970	gal.		.61
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.		.24
Hardwood oil, f.o.b. Mich., sp. gr., 1.06-1.08	gal.		.24
Pinewood creosote, ref.	gal.		.48

Naval Stores

The following prices are F.o.b., New York, for carload lots.

Rosin B-D, bbl.	280 lb.	$12.50 —	$12.70
Rosin E-I	280 lb.	12.60 —	13.40
Rosin K-N	280 lb.	13.50 —	14.50
Rosin W. G.-W. W.	280 lb.	15.00 —	15.50
Wood rosin, bbl.	280 lb.	12.25 —	.....
Spirits of Turpentine	gal.	.77½ —	.78
Wood Turpentine, steam dist	gal.	.72 —	.....
Wood Turpentine, dest. dist	gal.	.67½ —	.....
Pine tar pitch, bbls.	200 lb.	8.00 —	8.25
Tar, kiln burned, bbl. (500 lbs.)	bbl.	12.50 —	13.50
Retort tar, bbl.	280 lb.	13.50 —	14.50
Rosin oil, first run	gal.	.68 —	.78
Rosin oil, second run	gal.	.70 —	.80
Rosin oil, third run	gal.	.82 —	.83
Rosin oil, fourth run	gal.	.85 —	.95

SOLVENTS

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½

FISH OIL

Winter pressed Menhaden	gal.	$0.85
Yellow bleached Menhaden	gal.	.87
White bleached Menhaden	gal.	.89
Blown Menhaden	gal.	.95

Vegetable Oils

Unless otherwise noted, the following prices are f.o.b., New York.

Castor oil, No. 3, in bbls.	lb.	$0.22 —	$0.25
Castor oil, AA, in bbls.	lb.	.24 —	.25
China wood oil, in bbls.	lb.	.18 —	.19
Cocoanut oil, Ceylon grade, in bbls	lb.	.15 —	.15½
Cocoanut oil, Cochin grade, in bbls	lb.	.16½ —	.17
Corn oil, crude, in bbls.	lb.	.18 —	.17½
Cottonseed oil, crude (f.o.b. mill)	lb.	.17½ —	.....
Cottonseed oil, summer yellow	gal.	.21 —	.22
Cottonseed oil, winter yellow	gal.	.23 —	.25
Linseed oil, raw, car lots	gal.	1.50 —	1.53
Linseed oil, raw, tank cars	gal.	1.48 —	1.49
Linseed oil, boiled, car lots	gal.	1.53 —	1.55
Olive oil, commercial	gal.	2.25 —	2.50
Palm, Lagos	lb.	.15 —	.20
Palm, bright red	lb.	.13 —	.18
Palm, Niger	lb.	.12 —	.15
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.18½ —	.19
Peanut oil, refined, in bbls.	lb.	.19½ —	.21
Rapeseed oil, refined, in bbls.	gal.	1.50 —	1.65
Rapeseed oil, blown, in bbls.	gal.	1.65 —	1.70
Soya bean oil (Manchurian), in bbls., N. Y.	lb.	.15½ —	.16
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.14 —	.14½

Miscellaneous Materials

All Prices F.o.b., N. Y.

Barytes, domestic, white, floated	ton	$30.00 —	$36.00
Barytes, off color	ton	22.00 —	27.00
Blanc fixe, dry	lb.	.03½ —	.04½
Blanc fixe, pulp	ton	30.00 —	45.00
Casein	lb.	.17 —	.19
Chalk, English, extra light	lb.	.05 —	.07
Chalk, English, light	lb.	.04½ —	.06
Chalk, English, dense	lb.	.04 —	.05
China clay (Kaolin), imported, lump	ton	35.00 —	.....
China clay (Kaolin), imported, powdered	ton	60.00 —	.....
China clay (Kaolin), domestic, lump	ton	15.00 —	20.00
China clay (Kaolin), domestic, powdered	ton	35.00 —	40.00
Feldspar	ton	11.00 —	15.00
Fluorspar, acid grade, lump, f.o.b. mines	net ton	30.00 —	37.00
Fluorspar, acid grade, ground, f.o.b. mines	net ton	40.00 —	45.00
Fuller's earth, domestic, powdered	ton	30.00 —	40.00
Fuller's earth, imported, powdered	ton	..... —	.....
Graphite, domestic	lb.	.06 —	.12
Graphite, Ceylon	lb.	.08 —	.18
Graphite, Madagascar	lb.	.10 —	.15
Graphite, Mexican	lb.	.01¼ —	.03½
Pumice stone, imported	lb.	03 —	06
Pumice stone, domestic	lb.	None	
Shellac, TN	lb.	.47 —	.49
Shellac, D.C.	lb.	.73 —	.75
Shellac, V. S. O.	lb.	.72 —	.76
Shellac, Diamond I.	lb.	.72 —	.74
Shellac, orange, fine	lb.	.54 —	.57
Shellac, orange, superfine	lb.	.54 —	.58
Shellac, A.C. garnet	lb.	.47 —	.50
Shellac, bleached, bone dry	lb.	.57 —	.....
Shellac, bleached, fresh ground	lb.	.46 —	.47
Soapstone	ton	15.00 —	25.00
Talc, domestic	ton	20.00 —	60.00
Talc, imported	ton	Nominal	

Refractories

Following prices are f. o. b. works:

Chrome brick	net ton	$120.00 at Chester, Penn.
Chrome cement	net ton	65.00 at Cheater, Penn.
Clay brick, 1st quality fireclay	net ton	40–30 at Clearfield, Penn.
Clay brick, 2nd quality	net ton	38–48 at Clearfield, Penn.
Magnesite, dead burned	net ton	32.50–35.50 at Chewalah, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80–90 at Chester, Penn.
Silica brick	net ton	45–55 at Mt. Union, Penn.

Ferro-alloys

All prices f. o. b. works.

Ferro-titanium, carbon free	lb.	$0.40 —	.....
Ferro-carbon-titanium, 15-18%, f.o.b. Niagara Falls, N. Y.	net ton	$200.00 —	$300.00
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.32 —	.40
Ferro-chrome, per lb. of Cr. contained, 4-6% carbon	lb.	.70 —	.....
Ferro-manganese, 70-80% Mn	gross ton	130.00 —	150.00
Spiegeleisen, 16-20% Mn	gross ton	40.00 —	50.00
Ferro-molybdenum, per lb. of Mo	lb.	2.75 —	3.00
Ferro-silicon, 50%	gross ton	90.00 —	115.00
Ferro-silicon, 75%	gross ton	150.00 —	175 00
Ferro-silicon, 10-15%	gross ton	50.00 —	60.00
Ferro-tungsten, 70-80%, per lb. of contained W	lb.	1.30 —	1.60
Ferro-uranium, 35-50%, of U	lb.	7.00 —	.....
Ferro-vanadium, 30-40%, per lb. of contained V.	lb.	5.50 —	7.00

Resales and overstocks make above prices approximate.

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	0.70	
Chrome ore, 48% and over	unit	$1.00 —	$1.25
Coke, foundry, f.o.b. mines	net ton	4.50 —	5.00
Coke, furnace, f.o.b. mines	net ton	3.75 —	4.75
Petroleum coke, f.o.b. Atlantic seaboard	net ton	16.00 —	16.50
Fluorspar, gravel, f.o.b. mines	net ton	18.50 —	20.00
Manganese ore, 45% Mn and over	unit	.60 —	.85
Manganese ore, chemical (MnO_2)	gross ton	60.00 —	70.00
Molybdenite, 85% MoS, per lb. of MoS	lb.	.75 —	.85
Tungsten, Scheelite, 60% WO_3 and over per unit of WO_3	unit	8.00 —	10.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	7.00 —	10.00
Uranium oxide, 96%	lb.	..... —	.....
Vanadium pentoxide, 99%	lb.	6.00 —	.....
Pyrites, foreign, lump	unit	.17 —	.....
Pyrites, foreign, fine	unit	.17 —	.....
Pyrites, domestic, fine	unit	.14 —	.....
Ilmenite, 50% TiO_2	net ton	30.00 —	.....
Rutile, 95% TiO_2	net ton	200.00 —	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	3.00 —	3.25

Resales and overstocks make above prices approximate.

Plant Materials and Supplies

In carload lots, New York, unless otherwise stated.

BUILDING MATERIALS

Portland cement, at dock, without bags	bbl.	$2.30
Lump lime, common, including container	300 bbl.	2.65
Common brick, at dock	M.	15.00
Hollow building tile, } 8x12x12	M.	194.40
At factory, Perth Amboy, N. J., } 12x12x12	M.	291.60
Yellow pine, 3x4 to 8x8, 20-24 ft. long	M.	39.00
Yellow pine, 3x4 to 8x8, 20- 4 ft. long at Chicago	M.	38.50
Yellow pine, 3x4 to 8x8, 20-24 ft. long at St. Louis	M.	35.00
Roofings, tar felt (14 lb. per 100 sq.ft.)	ton	50.00
Roofings, tar pitch (in 400-lb. bbl.)	ton	19.00
Roofings, asphalt pitch	ton	30.00
Roofings, asphalt felt	ton	65.00
Roofings, slate-surfaced shingles, per roll of 108 sq.ft.		2.10
Roofings, slate-finished shingles, 100 sq.ft.		5.50
Linseed oil, raw in barrels	gal.	$1.63
Linseed oil, 5 gal. cans	gal.	1.76
Red lead, dry, 100 lb. keg	lb.	.13
Red lead, in oil, 100 lb. keg	lb.	.14½
Red lead, dry, 5 lb. cans	lb.	.15
Red lead, in oil, 5 lb. cans	lb.	.16½
White lead, dry and in oil, 100 lb. keg	lb.	.13
White lead, dry and in oil, 25 and 50 lb. kegs	lb.	.13½
White lead, dry and in oil, 5 lb. cans	lb.	15

STRUCTURAL STEEL, MILL, PITTSBURGH

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.66
Rivets, structural, ½-in. and larger	100 lb.	4.20
Rivets, cnnehead for boilers, ¾-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.35
Sheets, No. 10 blue annealed	100 lb.	3.55
Sheets, No. 28 galvanized	100 lb.	5.70

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

California

PASADENA—The city will join with South Pasadena and Alhambra in constructing sewerage treatment works on the tri-city sewer farm. Bond will be voted for project. R. V. Orbison, city engineer.

SACRAMENTO—The city plans election in May to vote on $2,400,000 bonds to purchase a site and build a filtration plant, pumping plant and caisson in the Sacramento River. F. C. Miller, City Hall, engineer.

SAN FRANCISCO—The Sherwin-Williams Co., 601 Canal St., Cleveland, Ohio, plans to build a paint and varnish factory here. Estimated cost between $250,000 and $300,000.

Connecticut

BRISTOL—The New-Departure Manufacturing Co., 269 North Main St., has awarded the contract for the construction of a 2-story, 30 x 103-ft. laboratory, to the Torrington Building Co., 197 Water St., Torrington. Estimated cost, $25,000.

HARTFORD — The Hartford Rubber Works, Park and Bath Aves., has awarded the contract for the construction of a 1½-story, 60 x 79-ft. factory on Bartholomew Ave., to J. H. Grozier Co., 221 Main St. Estimated cost, $34,000.

STORRS—The State Legislature, Capitol, Hartford, has appropriated $15,000 to build and equip a temporary laboratory for the Connecticut Agricultural College here.

Iowa

ROCK ISLAND—C. U. Scott & Son, 1338 2nd Ave., Davenport, plan to build a galvanizing, sheet metal and tempering plant on 1st Ave., between 15th and 16th Sts., here.

Kentucky

LEXINGTON—The W. J. Flescher Petroleum Co., 151 East High St., plans to build a refinery having a daily capacity of from 3,000 to 5,000 barrels.

Louisiana

BATON ROUGE—The Island Oil Co., 62 Cedar St., New York City, a subsidary of the New York Stock Exchange, Stock Exchange Building, New York City, plans to build a refinery here.

Maryland

HAGERSTOWN—The American Agricultural Chemical Co., capitalized at $100,000,000, has purchased three farms near here and plans to build a chemical and fertilizer plant.

Massachusetts

CHICOPEE—The Paper Makers' Chemical Co., Holyoke, plans to build a 1- and 2-story, 300 x 500-ft. paper factory on Grattan St., here. Estimated cost, $100,000.

CLINTON—The city plans to build a filtration system. Parker & Bateman, city engineers.

STOUGHTON—The United States Rubber Co., Broadway and 58th St., plans to build an addition to its factory here.

WORCESTER — The Greenman Steel Treating Co. plans to build a 1-story, 40 x 80-ft. plant.

Michigan

DETROIT—The Board of Water Commissioners, 232 Jefferson Ave., has awarded the contract for furnishing 100,000 lb. of liquid chlorine to the Hooker Electro Chemical Co., 40 Wall St., New York City, N. Y., at $.05¼ per lb.

DETROIT—The General Motors Corp., Boyer-Campbell Bldg., is having plans prepared by A. Kahn, architect, Marquette Bldg., for the construction of a 4-story, 60 x 480-ft. research laboratory building on Cass and Milwaukee Aves., same to be equipped with apparatus for a complete chemical, metallurgical and material testing laboratory.

HIGHLAND PARK—The city will soon award the contract for the construction of a filtration plant, to include a 2-story, 29 x 32-ft. head house and a 3-story, 32 x 85-ft. filter house, for the Dequindre Ave. Station of the Highland Park waterworks. D. C. Gewing, city clerk.

JACKSON—The city is having a study made by Alvord & Burdick, engineers, 8 South Dearborn St., Chicago, Ill., for the construction of a sewage disposal system to consist of deep settling tanks and intercepting sewers.

MONROE—The city plans to build a filtration plant. J. White, city engineer.

Minnesota

KEEWATIN—The city has awarded the contract for building extensions to its sewerage system and a sewage disposal plant to E. W. Coons Construction Co., Hibbing, at $59,184.

Missouri

CARONDOLET (St. Louis P. O.)—The Mineral Refining & Chemical Corp. will receive bids about June 1 for the construction of a paint and pigment plant on the Mississippi River front. Plans include a chemical laboratory, mineral milling plant, etc. Estimated cost, $2,500,000. M. Alayo, vice-president.

Nebraska

OMAHA—The Board of Education will install six laboratories in the new High School of Commerce which it plans to build. F. W. Clark, 623 Brandeis Building, architect.

New Jersey

ASBURY PARK—The Victory Tire & Rubber Co., 385 East 149th St., New York City, N. Y., plans to build a 2-story rubber factory on Railroad Ave. Estimated cost, $125,000. E. A. Arend, Kinmoth Building, architect.

HILLSDALE—The Bristol-Myers Co., 277 Greene Ave., Brooklyn, N. Y., has awarded the contract for the construction of a 1-story, 75 x 95-ft. extension to its chemical building, and a 5-story, 80 x 300-ft. manufacturing building, to the Turner Construction Co., 244 Madison Ave., New York City, N. Y.

TRENTON—The city plans to build a 2-story alum plant on Enterprise Ave. Estimated cost, $10,000. J. R. Fell, 134 North Clinton Ave., engineer.

New York

BROOKLYN—The Polytechnic Institute, 85 Livingston St., is in the market for two steel measuring or storage tanks, to be installed in its hydraulic laboratory for cold water storage.

GREENFIELD—The Waco Development Co., recently incorporated, plans to build a plant here. Mining machinery for feldspar mining will be installed in same. Address E. H. Cohen, 236 Union St., Schenectady.

MALDEN BRIDGE—The Gatti-McQuade Paper Co., 200 5th Ave., New York City, has purchased the Peaslee Mills here and is having plans prepared for repairing and altering same for its own use. Estimated cost, $25,000.

MILTON—The Waco Development Co., recently incorporated, plans to build a plant here. Mining machinery for feldspar mining will be installed in same. Address E. H. Cohen, 236 Union St., Schnectady.

NEW YORK—The Crystal Chemical Co., 861 Westchester Ave. (Bronx Borough), has awarded the contract for altering its 6-story, 40 x 70- and 30 x 42-ft. factory at 142-146 Willis Ave., to W. L. Phelan, 2045 Ryer Ave. Estimated cost, $25,000.

ROCHESTER—The Industrial Development Committee, Chamber of Commerce, is having plans prepared for a large shipyard on the lower Genesee River near lake harbor. A cement testing laboratory will be installed in same.

ROCHESTER—The Technical Glass Apparatus Co., Inc., plans to extend its facilities and install new machinery for the manufacture of scientific and laboratory glassware. F. C. Mueller, president.

TUCKAHOE—The Hodgeman Rubber Co. has awarded the contract for the construction of a 1-story, 50 x 150-ft. factory to Kelly & Kelly, East 12th St. and Vernon Ave., Long Island City. Estimated cost, $15,000. Noted Mar. 15.

North Carolina

BREVARD—The Transylvania Tanning Co. plans to rebuild its plant recently destroyed by fire, entailing a loss of $1,000,000.

Ohio

AKRON—The Mohawk Rubber Co., 2nd Ave., has awarded the contract for the construction of a 60 x 200-ft. rubber factory to W. A. Franklin Sons Co., 247 Cuyahoga St. Estimated cost, $50,000.

CINCINNATI—The city plans to build a garbage incinerator. Bonds must be voted for the project. F. Krug, city engineer.

CLEVELAND — The Commissioner of Purchases & Supplies, Room 219, City Hall, will receive bids until May 6 for the construction of a sewage disposal plant on West 58th St. (westerly site).

COLUMBUS—The American Rolling Mills Co. is receiving bids for extensive remodeling and new construction work at its plant along the tracks of the Toledo & Ohio Central R.R. on Parsons Ave. Work includes relining two furnaces, putting in eight hot-blast stoves, raising number of former stoves and building gas dry cleaning plant. Estimated cost between $300,000 and $400,000. J. C. Miller, Middletown, local manager.

NEWPORT—The city plans to build a garbage incinerator.

WAUSEON—The city plans election soon to vote on $170,000 for the construction of a water supply and filtration plant.

Pennsylvania

BEAVER FALLS—The city plans an election soon to vote on $125,000 bonds; part of proceeds to be used for the construction of a new sewage disposal plant. H. T. Barker, city clerk.

ELLWOOD CITY—The city plans an election soon to vote on $85,000 bonds; part of proceeds will be used for the construction of a disposal plant.

REYNOLDSVILLE—The Elk Tanning Co. plans to enlarge its plant here.

Texas

DALLAS—The Texas Producing & Refining Co., recently incorporated with $5,000,000 capital, plans to build an oil refinery here. The plant will be constructed in units, the first to have a capacity of 4000 bbl. daily, with other units added until the ultimate capacity will reach 15,000 bbl. daily. J. F. Smith, Southwestern Life Building, president.

DUBLIN—The State Refining Association has purchased a site here and plans to build an oil refinery. B. R. Anderson, president.

EASTLAND—The Alamo Oil & Refining Co. has purchased a site and plans to build a 1200-bbl. oil refinery.

EL PASO—Z. T. White, 527 First National Bank Bldg., and associates plan to build a 3000-bbl. oil refinery here.

FT. WORTH—F. P. Peterson, 307 West 4th St., and others, plan to form a company and build a plant for the manufacture of paints, grease, lubricating oils and floor sweep compound, on a site now occupied by the Brewton Oil Co., North Main St. and the Frisco tracks.

HOUSTON—The Galena-Signal Oil Co., 17 Battery Pl., New York City, N. Y., plans to increase the capacity of its oil refinery on the ship channel, near here, to 16,000 bbl. per day.

RANGER—The city has awarded the contract for the construction of a new

sewerage system and sewage disposal plant to the James Construction Co., 812 2nd Ave. N., Seattle, Wash. Estimated cost, $155,000. Noted Feb. 1.

Utah

CASTLEGATE—The Rainbow Petroleum Products Co., 4th and 5th West and 7th and 8th South Sts., Salt Lake City, plans to build the first unit of its new plant on the oil shale property near here, same to have a daily capacity of 100 tons.

Virginia

NORFOLK — The Mexican Petroleum Corp., Whitney Bldg., New Orleans, La., plans to build a plant here. W. E. Wimbish, manager.

PETERSBURG — W. H. Camp, Inc., Wharf, plans to build a 1-story fertilizer plant, and is in the market for machinery for mixing chemicals. Estimated cost, $55,000.

West Virginia

MARTINSBURG—The city plans to build a sewerage system and sewage disposal plant. T. W. Sparrow, city engineer.

Wisconsin

GREEN BAY—Kimberly & Clark, Neenah, plans to build a 2-story, 30 x 90-ft. addition to its paper mill here. Estimated cost, $20,000.

MANITOWOC—The Aluminum Goods Manufacturing Co., 150 Franklin St., has awarded the contract for the construction of a 6-story, 70 x 430-ft. factory and office building to W. W. Oeflein, 136 Hanover St., Milwaukee. Estimated cost, $500,000.

SHEBOYGAN—The Dodge Tanning Co., South Water St., has awarded the contract for the construction of a 3-story, 100 x 250-ft. tannery to H Loesing, 914 Superior Ave. Estimated cost, $60,000.

TWO RIVERS—The Aluminum Goods Manufacturing Co., 150 Franklin St., Manitowoc, has awarded the contract for the construction of two 3-story, 60 x 200 and 42 x 137-ft. factory buildings to W W. Oeflein, 136 Hanover St., Milwaukee. Estimated cost, $500,000.

Ontario

DUNDAS—The Town Council plans to build a sewage disposal plant. Estimated cost, $50,000. J. S. Fry, clerk.

TORONTO—W. Harris & Co. will soon receive bids for the construction of a 4-story, 66 x 145-ft. glue factory on Keating St. A Chapman, Harbor Building, architect.

Quebec

LAC AU SAUMON—The Salmon Lake Drive & Boom Association, Ltd., plans to build a large wood and pulp plant.

Mexico

PALO BLANCO—The Island Oil Co., 62 Cedar St., New York City, N. Y., a subsidary of the New York Stock Exchange, Stock Exchange Bldg., New York City, plans to build a refinery here.

Coming Meetings and Events

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its Summer meeting at Boston, Mass., June 18-21. A symposium is planned on electric furnaces.

THE AMERICAN ASSOCIATION OF ENGINEERS will hold a meeting at 29 S. LaSalle St., Chicago, May 13 and 14.

THE AMERICAN IRON & STEEL INSTITUTE will hold its next meeting on May 23-24 at the Hotel Pennsylvania, New York.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its 22nd annual meeting at Atlantic City, N. J., June 24-27. The headquarters will be at the Hotel Traymore.

THE AMERICAN ZINC INSTITUTE will hold its annual meeting at St. Louis, Mo., June 9-10.

THE NATIONAL FERTILIZER ASSOCIATION will hold its 26th annual convention the week of June 23 at the Hotel Griswold, Eastern Point, New London, Conn.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its Spring meeting, June 11-14 inclusive.

THE NEW JERSEY CHEMICAL SOCIETY will hold its Spring invitation meeting in the Chemical Building, Rutgers College, New Brunswick, N. J., Saturday, May 10, 1919. Dinner will be served in the University dining hall at 7 P. M.

Industrial Notes

MR. OTTO MANTIUS has moved his offices from the Woolworth Bldg. to 15 East 40th St., New York City.

MR. FREDERICK H. MINARD announces that on May 1 his offices will be moved to larger quarters at 21 East 40th St., New York City.

THE CHICAGO PNEUMATIC TOOL CO., Chicago, Ill., announces the appointment of Mr. T. J. Hudson as acting manager of the pneumatic tool sales division, effective April 15, 1919, succeeding Mr. F. H. Waldron, who returns to Minneapolis as district manager of sales in that territory.

THE SCHAFFER ENGINEERING & EQUIPMENT CO. has changed its location from Tiffin, Ohio, to the Peoples Bank Bldg., Pittsburgh, Pa.

MR. FRANK H. NICKLE, Saginaw, W. S., Mich., has placed on the market several styles of agitator driving yokes, suitable for all kinds of liquid containers.

New Publications

NEW UNITED STATES GEOLOGICAL SURVEY PUBLICATIONS: Natural-Gas Gasoline in 1917. By John D. Northrop (Mineral Resources, 1917, Part II), published March 17, 1919; I:II, Gold, Silver, Copper and Lead in South Dakota and Wyoming in 1917. By Charles W. Henderson (Mineral Resources, 1917, Part I), published Jan. 27, 1919; I:12, Gold, Silver, Copper, Lead and Zinc in Utah in 1917. By V. C. Heikes (Mineral Resources, 1917, Part I), published Feb. 8, 1919; I:13, Gold, Silver, Copper, Lead and Zinc in California and Oregon in 1917. By Charles G. Yale (Mineral Resources, 1917, Part I), published Feb. 18, 1919; I:14, Gold, Silver, Copper, Lead, and Zinc in Nevada in 1917. By V. C. Heikes (Mineral Resources, 1917, Part I), published Feb. 18, 1919; I:15, Secondary Metals in 1917. By J. P. Dunlop (Mineral Resources, 1917, Part I), published Feb. 19, 1919. I:16, Gold, Silver, Copper, Lead and Zinc in Montana in 1917. By V. C. Heikes (Mineral Resources, 1917, Part I), published Feb. 21, 1919; I:24, Quicksilver in 1916. By H. D. McCaskey (Mineral Resources, 1916, Part I), published Feb. 19, 1919; I:25, Cobalt, Molybdenum, Nickel, Titanium, Tungsten, Radium, Uranium and Vanadium in 1916. By Frank L. Hess (Mineral Resources, 1916, Part I), published Feb. 25, 1919; II:23, Sodium Salts in 1917. By Roger C. Wells (Mineral Resources, 1917, Part II), published Jan. 27, 1919; II:24, Cement in 1917. By Ernest F. Burchard, with a section on concrete ships by Robert W. Lesley (Mineral Resources, 1917, Part II), published Feb. 4, 1919; II:25, Sand and Gravel in 1917. By W. Stone (Mineral Resources, 1917, Part II), published Feb. 21, 1919; II:26, Potash in 1917. By Hoyt S. Gale and W. B. Hicks (Mineral Resources, 1917, Part II) published March 13, 1919.

NEW BUREAU OF MINES PUBLICATIONS: Bull. 174, Abstracts of Current Decisions on Mines and Mining, reported from May to September, 1918. By J. W. Thompson; Tech. Paper 96, Fume and Other Losses in Condensing Quicksilver from Furnace Gases. By L. H. Duschak and C. N. Schuette; Tech. Paper 203, Labor Saving at Limestone Quarries. By Oliver Bowles; Tech. Paper 215, Accidents at Metallurgical Works in the United States During the Calendar Year 1917. Compiled by Albert H. Fay; Tech. Paper 217, Saving Coal in Steam Power Plants. Reprint of Engineering Bull. No. 2, prepared by the U. S. Fuel Administration in collaboration with the Bureau of Mines; Tech. Paper 221, Saving Steam in Industrial Heating Systems. Reprint of Engineering Bull. No. 6, prepared by the U. S. Fuel Administration in collaboration with the Bureau of Mines; War Minerals Series No. 10, Electric Smelting of Domestic Manganese Ores. By H. W. Gillett and C. E. Williams; Schedule No. 13, March 5, 1919. Procedure for Establishing a List of Permissible Self-Contained Mine Rescue Breathing Apparatus.

NEW BUREAU OF STANDARDS PUBLICATIONS: Technologic Paper No. 109, Conservation of Tin in Bearing Metals, Bronzes, and Solders. By G. K. Burgess and R. W. Woodward, issued March 15, 1919; Circular No. 78, Solders for Aluminium, issued Jan. 28, 1919; Technologic Paper No. 114. A Portable Cubic-Foot Standard for Gas. By M. H. Stillman, issued January 28, 1919, price, 5 cents.

THE YOUNGSTOWN PUBLIC LIBRARY has inaugurated a service for vocational study that may well be copied by other city libraries. It has issued a 12-page booklet on the industries of Youngstown, put up in an attractive two-color cover carrying an industrial design of a blast-furnace plant. The following subjects are covered: General engineering, mechanical engineering, steam engineering, electrical engineering, machine design, machine shop practice, general chemistry, analytical chemistry, industrial chemistry, fuels, coal-tar by-products, general metallurgy, iron and steel, electric furnaces, rubber, etc.

"THE SURFACE OXIDATION AND COLORATION OF METALS" is the subject of a pamphlet published by Dr. Tito Rondelli, 31 Via Carlo Alberto, Turino, Italy, setting forth the details of the "Sestini-Rondelli" electrolytic process.

Stocks and Bonds

Closing Bid and Asked Quotations April 25, on N. Y. Stock Exchange

CHEMICAL COMPANIES

	Bid	Ask		Bid	Ask
Am.Ag.Ch.....	100⅛	100⅞	Mat.Al.Wk..	31	36
do.pf.....	99	100	Ten. C. & C..	14⅜	14½
Barrett Co...	127	128	Un. Dyewood.	60	61
do.pf.....	114	115	do. pf.....		96
Gen.Chem.....	170	180	Va.-Car. Ch..	51⅛	51⅜
do.pf.....	102½	103¼	do. pf.....	111¼	112½
Int.Ag.Ch....	18⅛	19⅛			
do. pf.....	73½	74			

Bonda

Am. Ag. Ch., 1st cv. 5s, '28.....	98⅛	90⅛
Am. Ag. Ch., cv. db. 5s, '24.....	104	105
Int. Ag. Ch., 1 mtg. & col. tr. 5s, '32....	81⅛	81½
Va.-Car. Ch., 1 mtg. 5s, '23	95½	95⅔
Va.-Car. Ch., cv. db. 6s, '24.....	101½	101½

PETROLEUM COMPANIES

	Bid	Ask		Bid	Ask
Asso. Oil Co..	81⅛	82	P-A Pet & Tr.	82⅛	83
Cal. Pet.....	27	27⅛	do. pf.....	144	146
do. pf.....	71	72	Pierce Oil....	24	24⅛
Col. G. & E..	45½	46	Royal Dutch..	99⅜	99⅞
Mex. Pet.....	181⅛	182	Sinclair O & R	55⅝	55⅞
do. pf.....	107	110	Texas Co...	218⅛	219
Ohio Cit. Gas.	40⅛	41	Tex. Pac. Ld.		
do. pf.....			Tr.....	280	325
Ohio Fuel S..	47	48	Tidewater Oil.	227	230
Okla. P. & R..	10⅛	10½			

Bonda

Columbia Gas & Electric, 1 5s, '27.....	84⅛	85½
Col. G. & El., std. 1 5s, '27	83	89
Pan-Am. Pet. & Tr. 1 6s, '19-'27.....	130	
Pierce Oil, cv. db. 6s, '24.....	105	106½
Pierce Oil, cv. 5% Notes, '20.....	114	122
Sin. O. & R. 1 In.7s, '20, with atk. war...	119	121⅛
Sin. O. & R. 1 In. 7s, '20 without stk. war..	98⅞	99½
Texas Co., db. 6s, '31.	102	103
Union Oil of Cal. 1 5s, '31.	93	94
United Fuel Gas 1 mtg. 6s, aer.A, '36.....	94½	97

IRON AND STEEL SECURITIES

	Bid	Ask		Bid	Ask
Am. St. F.....	....	....	Pitts.Ste.pf...	93⅛	100
Beth. Steel...	73⅛	75½	Rep. Iron &		
do. class B.	74½	74⅞	Steel.....	82	82½
do. pf., 8%.	109	110½	do. pf....	102½	103⅛
do. pf., 7%.	97	99	Sloss Sheff. I.		
Central Fdry.	15	....	& S.....	53	54
do. pf.....	29	....	do. pf.....	86	90
Col. F. & I....	42½	43⅛	Superior Steel.	38	39⅛
do. pf.....	105	125	do. 1 pf....	97	98⅛
Cruc. Steel...	68	68½	Trana. & W.		
do. pf.....	93	97	Steel.....	46⅛	47
Great No. Ore	43⅛	44	Un. Alloy St..	42⅜	43
Gulf Sta. Steel	54⅛	55	U.S.C.I.P.&F.	25⅛	26
do. pf.....	92⅛	98⅛	do. pf.....	53	53⅞
Lack. Steel..	70⅜	71⅛	U. S. Steel....	100	100⅛
Mid.St.& Ord.	45⅜	45⅞	do. pf....	115⅛	117
Nova Scotia			Va. Coal, I&C.	55	57
Steel	50	54			

Bonds

Beth. Steel, 1 ext. gtd. S.F. 5s, '26.....	96	96⅛
Beth. Steel, 1 In. ref. 5s, Ser. A, '42.....	86⅛	87⅛
Beth. Steel, P. M. & I. S. F. 5s, '36.....	85	8 ⅛
Buff. & Susq. Iron, 1 S. F. 5s, '32.....	91	96
Buff. & Susq. Iron, deb. 5s, '27		
Cent. Found. 1 mtg. S. F. 6s, '21.....	76	80⅛
Col. F. & I., gn. S. F. 5s, '43	89⅜	91
Ill. Steel, db. 4½s, '40	84	85
Ind. Steel, 1 mtg. gtd. 5s, '52.....	96⅛	96⅛
Lack. Steel, 1 5s, '23.....	96⅛	97
Lack. Ste., 1 con. mtg. cv. 5s, Ser. A, '50	87	91⅛
Mid. St. & Ord., cft. cv. S. F. 5s, '36.....	88⅛	88⅛
Nat. Tube, 1 mtg. gtd. 5s, '52.....	95⅛	96
Rep. I. & S., S. F. mtg. 5s, '40.....	93½	94
Tenn. C. & I. R.R., gn. 5s, '51.....	92	95⅛
U. S. Steel, S. F. 5s, '63.....	100⅛	100⅛
Va. C., I. & C., 1 5s, '49.....	85	85⅛

Published SEMI-MONTHLY *on the* FIRST *and* FIFTEENTH *of each month*

CHEMICAL & METALLURGICAL ENGINEERING

A *consolidation of* ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

McGRAW-HILL COMPANY, INC.
Tenth Avenue at 36th Street
NEW YORK

JAMES H. McGRAW, President
ARTHUR J. BALDWIN, Vice President E. J. MEHREN, Vice President
J. MALCOLM MUIR, Vice President EDWARD CALDWELL, Treasurer
JAMES H. McGRAW, JR., Secretary

TELEPHONE, 2840 Greeley CABLE ADDRESS, Machinist, New York

WASHINGTON, Colorado Bldg. SALT LAKE CITY, Newhouse Bldg.
CHICAGO, Old Colony Bldg. PHILADELPHIA, Real Estate Trust Bldg.
SAN FRANCISCO, Rialto Bldg. CLEVELAND, Leader-News Bldg.
LONDON, 6 Bouverie St., E. C. 4. BUENOS AIRES, Calle Corrientes, 685.

H. C. PARMELEE, Editor
ELLWOOD HENDRICK, Consulting Editor
ERNEST E. THUM, Western Editor
WALLACE SAVAGE, Assistant Editor

Yearly Subscription price for United States, Mexico and United States dependencies, $3; all other countries, $4. Single Copy, 25c.
When change of address is ordered, the NEW and the OLD addresses must be given. Notice must be received at least 10 days before change takes place. No back copies for more than three months.

Copyright, McGraw-Hill Co., Inc., 1919. Entered as second-class matter July 13, 1918, at the Post Office at New York, N. Y., under the Act of Congress of March 3, 1879.

Circulation of this issue 12,300 *copies*

CONTENTS *for May* 15, 1919

Volume XX, *Number* 10

EDITORIAL
The Rude Awakening 497
An Opportunity for Co-operative Research 498
Scholarships in Sweden 498
Cinematic Micrography 499
Government Control of Markets 499

READERS' VIEWS AND COMMENTS
Economics in the Zinc Industry. By *E. M. Johnson* 500
That Missing Page From the Blue-Back Speller. By *H. M. Howe* 501
Work of the Bureau of Standards on Electroplating. By *S. W. Stratton* 501
Decomposition of Metals. By *A. I. Krynitsky* 501
The Oxidation of Ammonia 502
Modern Training of the Chemical Engineer 503
American Scientific Glass 504
American Institute of Chemical Engineers, Boston Meeting 504
Surplus Government Supplies 505
Spring Meeting of the T. A. P. P. I. 505
Chicago Meeting, A. I. M. E. 505
Industrial and Academic Co-operation 505
Exchange of American-Scandinavian Scholarships 505
Photography in Research. By *Arthur G. Eldredge* 506
An Improved Method of Optical Glass Manufacture. By *George W. Morey* 511
Some Wild Engineering Ideas Known. By *David Wesson* 512
A Proposed Metallurgical Process for the Treatment of Vanadinite for the Recovery of Lead and Vanadium. By *J. E. Conley* 514
Japanese Industrial Notes 518
Fundamental Principles to Be Considered in the Heat Treatment of Steel. By *R. A. Hayward* 519
Determination of Uranium, Zirconium, Vanadium and Aluminum in Steel—I. By *Charles Morris Johnson* 523
Continuous Distillation of Tar 524
Sintering Zinc Residues. By *K. Stock* 525
Removal of Limitations on Export of Silver 528
Research Fellowships at University of Idaho 528
Americanization Work by the Colorado Fuel & Iron Co. 529
Metallic Coatings for Rust-Proofing Iron and Steel—II. By *Henry S. Rawdon, M. A. Grossman* and *A. N. Finn* 530
Hand Device for Flotation Experiments. By *Will H. Coghill* 537
Improved Form of Granular Carbon Resistance Furnace for Fusion Point of Coal Ash and Firebrick. By *C. H. Lovejoy* 538
Chemical Specifications. By *Wallace P. Cohoe* 539
Sale of Picric Acid Plant 540
Synopsis of Recent Chemical and Metallurgical Literature 541
Recent Chemical and Metallurgical Patents 544
Personal 545
Current Market Reports 545
Industrial News 550

The Rude Awakening

IT WAS not to be expected that the Germans would receive the treaty in the spirit of defeated sportsmen, for as has been pointed out in this journal there is no equivalent in their language for the English word "sportsman," and the German mind probably is devoid of an instinct for which it has no distinctive word. And speaking of words not in the German dictionary, MR. JAMES M. BECK commented in a speech before the English-Speaking Union in London on the absence of any equivalent in German for the English exclamation "Bully!" " It seems strange," he added, "because they give so many exhibitions of the characteristics of the bully."

Throughout the war German psychology has been a source of wonderment to the rest of the world, because just when the mystery of it seemed to be understood, new and strange phases were exhibited. The arrogance and insolence displayed when they were apparently winning the war and which led them to announce boldly the terms which they would exact of their defeated enemies are exhibitions of the same spirit that now whines over the realization of its defeat. Whom the gods would destroy they first make mad, and the German madness of the last forty years which led to their idea of world conquest certainly has wrought their destruction.

During the Spanish war we had the slogan "Remember the Maine!" but there are so many things to remember in the late war that the mind instinctively falls back upon a card index and a corps of clerks. It behooves us to remember! It's worth recalling some of the unpleasant, disagreeable and atrocious things done by the Germans in this war, if for no other reason than to preserve our balance when the whining and bluffing and mock heroics are indulged in. MR. FRANK H. PROBERT, who recently visited Europe for the Bureau of Mines, traversed the iron-bearing areas of Nancy, Briey, Longwy and Luxemburg, and the coal-bearing regions of Saar and Pas de Calais. He returns with the same story of frightfulness which impresses all who have had an opportunity for personal inspection of those districts.

MR. PROBERT says:

"The mines are not seriously crippled, but what of the steel plants in which the iron ore was smelted? No such atrocity was ever perpetrated against the industrial life of any country. Magnificent plants, comparing favorably with anything we have in the United States, are now but a tangled, twisted mass of structural steel and broken stone. The willful demolition was scientifically planned and systematically carried out. This after the removal of all such mechanical and electrical power units as could be used in Germany. The maliciousness and efficiency with which this crime

against French industry was conducted is almost unbelievable."

So much for the iron and steel industry. Of the French coal fields MR. PROBERT says: "The coal measures are overlain by water-bearing strata, necessitating special methods of shaft sinking and support to keep the mines dry. The steel lining of the shafts was dynamited, letting in the quicksands and flooding the underground workings for many miles. In the entire Pas de Calais region it is estimated that 120 million cubic meters of water must be pumped before mining operations are resumed. Having flooded the mines, the headframes and surface equipment were systematically dynamited, the twisted débris in many cases filling up the demolished shafts. It will probably be five years before this coal district can be rehabilitated and twelve to fifteen years before it gets back to normal pre-war output."

And in contrast to these conditions, the coal industry in the Saar is at the height of production! Meantime Germany calls upon us in the name of humanity, consience, justice—qualities which she has never shown—to have regard for her pitiful estate. The thing which most concerns us now is to stand firmly by the terms of a treaty which has been fairly drawn.

An Opportunity for Co-operative Research

ELSEWHERE in this issue we publish a letter from the Director of the Bureau of Standards calling attention to the decision of the Bureau to devote the sum of $10,000 to research in electroplating. While a good start will be made with this amount, it is apparent that much larger sums should be available in order to prosecute the work vigorously. At the moment we can think of no more appropriate donors of funds than those who would profit most from the results, viz., the electroplaters, and we take advantage of the opportunity to suggest an organization in their ranks for co-operative industrial research.

We speak not unkindly of our friends the electroplaters when we say that the impression prevails that their art has been based on rule-of-thumb development and secret formulæ rather than on scientific investigation and knowledge. Studies made during the war disclosed some fearful and wonderful solutions and "dopes," and brought to light methods and processes as archaic as they were unreasonable. On the other hand, some of the war tasks imposed on electroplaters showed them capable of getting remarkable results.

Our thought is that electroplaters can profit in a marked degree if they will get together and support a research into the fundamentals involved in their business. There is a fertile field of metallurgy, electrochemistry and physics in their art that would respond quickly to cultivation. There is no need to fear disclosure of trade secrets, many of which, by the way, probably would be found valueless; nor would the incentive to private initiative be removed, or the profits from superior skill be lost. These things are aside from the scientific groundwork of the art which would be investigated and elucidated for the benefit of all concerned. A few years of work by enthusiastic men who are now available would contribute more to the advancement of electroplating than anything we can think of, and the cost would be nominal when divided among the large concerns in the industry.

Scholarships In Sweden

WE TAKE pleasure in printing elsewhere in this number the announcement of ten scholarships available for American students in science to continue their studies and research in Sweden, with the information that ten similar scholarships of $1000 per year each have been provided for Swedish students to study in the United States. The American-Scandinavian Foundation of New York has secured the benefaction.

Of course we shall welcome the Scandinavian students here. We are glad to have them come, and hope they may find the enlightenment they desire in our various institutions. We are especially interested, however, in the opportunities for American students in Swedish universities and technological schools. For many years they have been addicted to good scientific habits in that country, and their teaching methods are at once thorough and sound. We have examples of this in PROFESSORS KENDALL of Columbia and TAYLOR of Princeton, both of whom started physical chemistry with no less a person than ARRHENIUS. Who wouldn't like to study physical chemistry under him!

Of course there is the language problem to be met by the stiff American tongue which adjusts itself with remarkable unwillingness to anything but "plain United States," but what with Polish and Russian and all the other Slavonic languages that claim attention, and the admitted requirements of French and Spanish, we see gala days ahead for the language teacher. Swedish should not be more difficult than German, which most of us engaged in science have tackled at one time or another.

The advantages of study in Sweden are peculiar, and students should profit by sojourning in communities in which certain things are better managed than at home. Thus the Swedes know how to take care of their forests, which we do not. Or, if we do know how, we do not put this knowledge into public practice, which is even more inexcusable than ignorance would be. Again, while we have pulp and paper mills that are remarkable examples of applied science, it is a fair guess that, taken by and large, there is better chemical control of this industry in Sweden than in the United States.

In the safety-match industry, although it was imported from Sweden, we turn out better material than do they at present, but we do not know where the better technology may be found. In applied electrochemistry they are well advanced, both in Sweden and Norway; a development which has followed their abounding water-power resources and the native disposition toward research.

They are grand metallurgists, and without attempting to make comparisons, it would be a great opportunity to study the subject in Swedish institutions. The same may be said in relation to pure science, more particularly physics and physical chemistry. Their methods are thorough; they take time enough to avoid the slapdash ways of some of our own institutions, and they have ideals of professional responsibility in science.

Granted the requisite character, intelligence and assiduity on the part of the ten young men to be chosen and to whom the opportunity of study in Sweden is offered, we think them lucky. If they come back to us speaking from their chests like some men from England engaged in an unfamiliar tongue, it will not confuse their speech. If they bring back legends of BEOWULF,

if they become inspired with Ynglinga Saga, if they repeat stories of GUSTAVUS ADOLPHUS and the Tenth and Twelfth Kings CHARLES and draw strange and exotic distinctions between hats and caps, it will do them no harm. And these things may lighten the idle hours of the rest of us. Such a Swedish slant will have a greater value in cultural influence than the convictions which in times past were sometimes brought back to the effect that the origins of righteousness and truth were centered in FREDERICK the Great and OTTO VON BISMARCK.

Cinematic Micrography

THOSE who have had the privilege of seeing the remarkable motion pictures of alternating stress failure exhibited by PROF. H. F. MOORE at the Society for Testing Materials or elsewhere during the past few months were greatly impressed by this recent application of the ubiquitous "moovies." Many of them were already familiar with the application of cinematography to motion study, where its possibilities have not even yet been fully exploited by scientific managers. In conjunction with the microscope, however, it remained for PROF. ARTHUR G. ELDREDGE of the University of Illinois to overcome the apparent difficulties which halted less intrepid investigators.

The layman could not dream of the possibilities of these well-known instruments, the motion camera and the microscope, even singly. Science is far too oblivious of their potency, especially in combination. Add the resources of the ultra-microscope and the ultra-visible rays, and the motion camera appears to be the key whereby the gate to vast areas of research may be opened. The outlook should be very attractive to educational and research institutions, and might well be the animus for revamping the all too meager photographic equipment they commonly possess.

PROFESSOR ELDREDGE'S brief discussion of the elementary principles underlying cinematic micrography appearing elsewhere in this issue should therefore be very interesting to research men, and it is hoped that this important contribution may result in many applications of such a powerful tool to future investigations of chemical and metallurgical engineering problems.

Government Control Of Markets

ONE hears very much less argument these days in favor of "government ownership" or "government control" of anything than was heard one short year ago, or even six months. Zealous JOHN WANAMAKER, when Postmaster General, explained that there were four reasons why the United States did not have a parcels post, those four reasons being the Adams Express Company, the United States Express Company, the American Express Company and the Wells-Fargo Express Company. The public now has several reasons why it does not favor government operation of utilities, among those reasons being government operation of the cables, of the Postal Telegraph-Cable Company, the Western Union and the railroads.

Better than all these reasons, however, because wartime necessity obtrudes itself when one endeavors to extract the essence, is the manner in which the Industrial Board program of "price deflation" or "price stabilization" worked out, for in it one is furnished the C. P. essence of the Washington politico-bureaucratic method of doing things and not accomplishing results.

Wordy as were the exchanges between the Industrial Board and the Railroad Administration before the former resigned, May 9, the remarks afterward made to the public by parties to the controversy quite outclass them. MR. PEEK announced—to the public—that "the public" would demand an explanation why the Industrial Board plan had been wrecked "apparently on the obstinacy of a single individual"—the Director General of Railroads—when "in theory the plan had been approved almost unanimously." Then MR. PEEK rapped the Secretary of the Treasury for taking "a stand in direct contradiction with his message urging the creation of the board." Finally he indicates the point of debarkation for the Attorney General by observing: "The Attorney General has rendered an opinion that the plan of the board contravenes the Sherman act, but the facts he assumes as the basis of that opinion are so inconsistent with the actual course of conduct of the board as to render the opinion inapplicable." To all or much of which the Secretary of the Treasury replies in a public statement that the Industrial Board "was hopelessly committed to an unsound and dangerous policy" and that "there is scarcely one accurate assertion or sane deduction in all the intemperate screed."

MR. PEEK had condemned himself in his statement. He asserted, which was true, that "in theory the plan had been approved almost unanimously," which obviously suggests that there must have been something wrong with the board's method of carrying out the theory, and so there was. The idea was that the board should act as an intermediary between seller and buyer, whereas it agreed only with the sellers and then sought to force the Railroad Administration to accept the terms, which the Railroad Administration refused to do. A function of the board was to be that of restoring the play of the law of supply and demand, but as a means of doing this it endeavored to fix steel prices for a period of nine months!

All these men were very likeable chaps before they went to Washington and got to doing things in a Washington atmosphere, which is the main reason why government operation of anything is to be avoided when it can be.

The Industrial Board acquired a misconception of the fundamental facts in the case, arrived at an improper conclusion, and then made it a personal issue to have others adopt its views. It was deceived as to the cost of making steel, accepting as applicable to the future certain statements of cost which included a heavy overhead because figured upon light operation of mills. The Industrial Board plan, however, contemplated the restoration of activity, and if that occurred the overhead would be much better distributed and the cost of production would be correspondingly lower. The steel producers, who know their market quite well, had no faith in an immediate resumption of constructional activity, and on that basis the reductions they accorded the Industrial Board must be considered large. Now the board is gone and the steel producers doubtless wish they had their old prices back again. And after all the wordy arguments of the past few weeks it is at last developed what the Railroad Administration would like to buy—200,000 tons of rails. That is one-fifteenth of one month's full output of finished steel.

Readers' Views and Comments

Economics in the Zinc Industry

To the Editor of Chemical & Metallurgical Engineering

SIR:—I certainly agree with the gentleman who wrote the article entitled Economics in the Zinc Industry in your issue of March 15, 1919, that roasting plays an important part in the smelting of zinc ores and that there is considerable room for improvement in the roasting of ores for the extraction of zinc, more especially with respect to the design of the roaster. From all the results and experiments I have made on samples from the kilns during the process of roasting, the indications are that sulphides do not pass by degrees to sulphates and then to oxides, but more directly to oxides. If this were not the case a greater percentage of the sulphates would be found at certain places along the bed of a mechanical roaster or at certain periods in hand-roasting.

The following results obtained on a hand-rabbled kiln show a low percentage of sulphates at all periods:

CHEMICAL DISTRIBUTION OF SULPHUR IN HAND-RABBLED KILN

Test No. 1

	SiO_2, Per Cent	Fe, Per Cent	Zn, Per Cent	Pb, Per Cent	Total S, Per Cent	Soluble Sulphates: Sol. H_2O S, Per Cent	Basic Sulphate Sol. Na_2CO_3 S, Per Cent	Total S, Per Cent	Sulphide S, Per Cent
Crude	1.8	10.7	47.1	5.2	33.8	0.066	0.08		33.65
Crude at 8:30	2.0	10.7	46.4	5.3	33.6	0.055	0.07		33.48
9:30 1st hour	...	....	....	...	28.8	0.1	0.01		28.65
10:30 2nd hour	...	....	....	...	26.7	0.077	0.077		26.55
11:30 3rd hour	...	....	....	...	22.4	0.11	0.15		22.14
12:30 4th hour	...	....	....	...	20.0	0.11	0.11		19.78
1:30 5th hour	...	....	....	...	17.2	0.13	0.21		16.86
2:30 6th hour	...	....	....	...	11.4	0.28	0.33		10.79
3:30 7th hour	...	....	....	...	8.8	0.14	0.23		8.43
4:30 8th hour	...	....	....	...	5.1	0.14	0.23		4.73
5:30 9th hour	...	....	....	...	1.9	0.19	0.31		1.40
6:30 10th hour	...	....	....	...	1.2	0.33	0.46		0.41
7:30 11th hour	...	....	....	...	0.9	0.30	0.47		0.13
8:30 12th hour Finished	7.4	11.8	53.1	3.5	0.9	0.38	0.44		0.08
Roasted ore	7.4	12.3	52.5	3.4	1.5	0.37	0.45		0.68

Test No. 2

	SiO_2, Per Ceut	Fe, Per Cent	Zn, Per Cent	Pb, Per Cent	S, Per Cent	Soluble Sulphates: H_2O S, Per Cent	Na_2CO_3 S, Per Cent	Total S, Per Cent	Sulphide S, Per Cent
Crude ore	1.6	10.4	46.7	5.5	34.0	0.066	0.11	0.18	33.82
9 a.m.	1.6	10.3	46.7	5.6	33.8	0.044	0.11	0.15	33.65
10 a.m.					27.5	0.12	0.12	0.24	27.26
11 a.m.					20.9	0.11	0.27	0.38	20.52
12 m.					23.6	0.12	0.25	0.37	23.23
1 p.m.					16.2	0.12	0.34	0.46	15.74
2 p.m.					14.6	0.14	0.33	0.47	14.13
3 p.m.					9.6	0.14	0.38	0.52	9.08
4 p.m.					6.7	0.10	0.33	0.43	6.27
5 p.m.					1.8	0.11	0.33	0.44	1.38
6 p.m.					0.94	0.11	0.46	0.57	0.37
7 p.m.					0.66	0.12	0.46	0.58	0.08
8 p.m.					0.66	0.13	0.52	0.65	0.01
9 p.m. Roasted ore	1.6	11.8	54.8	3.3	0.94	0.26	0.51	0.77	0.17
General aample roasted ore	1.6	12.0	54.8	3.5	1 65	0.26	0.52	0.78	0 67

Test No. 3

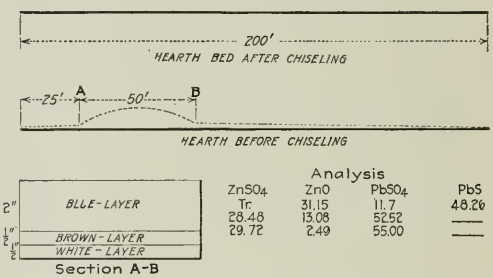
	SiO_2, Per Cent	Fe, Per Cent	Zn, Per Cent	Pb, Per Cent	S, Per Cent	Soluble Sulphates: H_2O S, Per Cent	Na_2CO_3 S, Per Cent	Total S, Per Cent	Sulphide S, Per Cent
Raw ore	1.6	10.2	46.8	5.7	33.8	0.055	0.10	0.16	33.64
Crude ore:									
11 a.m.	1.6	10.2	46.7	5.7	34.3	0.044	0.11	0.15	34.15
1 p.m.					19.5	0.76	1.17	1.93	17.57
3 p.m.					17.6	0.15	0.37	0.52	17.08
5 p.m.					16.6	0.15	0.34	0.49	16.11
7 p.m.					12.8	0.13	0.39	0.52	12.28
1 a.m.					2.9	0.11	0.56	0.67	2.23
3 a.m.					3.2	0.18	0.65	0.83	2.37
5 a.m.					2.3	0.25	0.78	1.03	1.27
7 a.m.					1.1	0.15	0.81	0.96	0.14
9 a.m., 2nd and 3rd	...	....	....	...	1.4	0.23	0.87	1.10	0.30
Finished 11 a.m., 2nd and 3rd.	1.6	11.3	53.4	5.0	2.5	0.72	1.19	1.91	0.59
Roasted ore, general sample	1.6	11.6	53.4	5.0	3.1	0.72	1.17	1.89	1.21

Test No. 4

	SiO_2, Per Cent	Fe, Per Cent	Zn, Per Cent	Pb, Per Cent	S, Per Cent	Soluble Sulphates: H_2O S, Per Cent	Na_2CO_3 S, Per Cent	Total S, Per Cent	Sulphide S, Per Cent
Crude, 9:45 a.m.	1.6	10.0	46.9	5.8	31.9	0.09	0.06	....	31.75
Roasted ore, 9:45 p.m.	4.6	11.8	55.6	2.4	0.6	0.2	0.29	....	0.11
Do	4.4	11.8	55.6	2.3	0.7	0.22	0.34	....	0.14

The following results show that the formation of sulphates is very slow and that the oxide of zinc and the sulphide of lead are changed to sulphates, and apparently without the action of much air or rabbling. These samples represent what is called the kiln bottom, and were taken from a Ropp roaster as shown by the sketch.

As the ore is moved forward by the rabble plows, the heavy galena entangled with a certain amount of zinc and iron sulphides is deposited between *A* and *B*, and



gradually grows or builds up to a thickness of from 6 in. to 10 in., when it has to be chiseled out. From the above experiment the indication would be that a thick bed moving slowly through the kiln is a better condition for roasting ores for electrolytic production of zinc than where the distillation process is used; and where the latter process is to be used the roasting kiln should be designed to give an instantaneous roasting condition as near as possible.

In 1913 the writer made the following experiment: A piece of tile $5\frac{3}{4}$ in. by 9 in. was covered with as thin a layer of ore as possible. The ore was then brushed off and weighed. The tile was then inserted into an assay muffle and heated to a good red heat, when it was withdrawn, and the weighed ore quickly spread over, and the tile with ore reinserted into the muffle. The following results were obtained:

	Green Ore Taken, Grams	Time in Muffle, Min.	Per Cent Sulphur
Joplin ore	45	10	2.80
Joplin ore	45	15	1.50
Western ore	45	10	4.07
Western ore	45	15	0.70

Now, as the amount of ore taken was 45 g. and the area of the tile was approximately 50 sq.in., there would be 0.9 g. per sq.in., or 129.6 g. per sq.ft. Taking the area of a regular kiln at 2250 sq.ft., we would have, if the ore were spread over the hearth as in the test, 2250 × 129.6, equal to 291,600 g.; or, dividing by 454, the number of grams in one pound, we would get 642 lb. of roasted ore every 15 min., which is equivalent to 61,632 lb. per 24 hr., based on green ore. This would be considered very good in actual practice. So far as the chemical reactions, heat and air are concerned the principle seems ideal, and it is only a matter of

working out the mechanical details of a suitable kiln. After making this experiment I concluded that a revolving hearth would be best suited to accomplish an instantaneous roast and went so far as to design one and apply for a patent, when I discovered that Mr. Wilfley had already covered the ground. As Mr. Wilfley had not followed up the subject with the installation of a practical roaster on a commercial scale, so far as I knew, I lost interest in the matter. It would be of interest, however, to learn from Mr. Wilfley his experience with the small roaster he built and tested, and whether he thinks there are possibilities along this line.

Henryetta, Okla. E. M. JOHNSON.

That Missing Page From the Blue-Back Speller

To the Editor of Chemical & Metallurgical Engineering

SIR:—Referring to your article "That Missing Page From the Blue-Back Speller" on page 794 of your issue of Dec. 15, I think your question as to the wisdom of adding cold solid additions in the ladle in making steel is pretty well answered by the fact that the steel should be poured at a temperature only very slightly above its liquidus or upper freezing point. Thus the casting temperature should be so low that a considerable skull is often left in the ladle. Moreover, pouring at a temperature materially above the liquidus causes external cracks on the sides of the ingot, from the fact that the rate of thickening of the solid walls of the ingot goes on so slowly as the column of molten steel rises that the ferro-static pressure becomes so great as to crack these walls. Under these conditions the margin of temperature between the freezing point and the existing temperature of the molten steel is so slight that the melting of any solid additions must be relatively slow. The last particles of the addition cannot begin to diffuse or to be spread by convection until they have actually melted. Indeed the molten steel has so slight a margin of temperature above its solidus that large quantities of it may be expected immediately to freeze about any cold solid ferromanganese that is thrown into it, quite as when one thrusts a cold iron rod into a pot of molten glass one will draw out a bunch of glass which may be much thicker than the rod itself. We shall thus have a mass consisting, first, of the cold ferromanganese, and, second, of an envelope probably many times larger than the manganese itself of plastic steel which has solidified about it. The melting of the manganese cannot begin till the whole of this resolidified steel has melted, and the diffusion of the whole of the manganese cannot begin till still later, when the last of the ferromanganese has melted.

Moreover, because the temperature is so much lower in the ladle than in the furnace, the activity of the manganese in removing the oxygen is materially less. This is no doubt the important reason why the loss of manganese is less when it is added in the ladle than when it is added in the furnace.

Actual practice shows that this is not an imaginary condition. In fact when manganese is added in the ladle it has been observed in many cases that the last ingot poured is materially richer in manganese than the first, indicating either that the manganese has been floated to the surface by means of the envelope of steel resolidified about it, or that there have been in effect successive additions of manganese to the molten metal by the successive meltings of the different lumps of ferromanganese, each surrounded with its own envelope of resolidified steel. As each became free from its envelope and in turn melted, it would become added to the molten metal and would no doubt diffuse rapidly through it. Hence the last ingot may be much richer in manganese than the first.

I have had the advantage of discussing this matter with Colonel Barba since reading your article, and I believe his recommendations represent not simply his own opinion, but the result of experience and widespread belief. H. M. HOWE.

Washington, D. C.

Work of the Bureau of Standards on Electroplating

To the Editor of Chemical & Metallurgical Engineering

SIR:—As was stated in January in the *Monthly Review* of the American Electroplaters' Society, efforts were made to secure from Congress a small special fund for work in this field. Owing to the many demands upon Congress at that time, it was not possible to secure this or numerous other special funds requested by the Bureau. However, in view of the importance of electroplating to many industries, and of the advantage of continuing the investigations now in progress, it has been decided to make an allotment of $10,000 for this work from the Industrial Research Fund recently appropriated to the Bureau for the year beginning July 1, 1919. Reports upon the progress and results of this work will be published from time to time in this and other technical journals, and in Bureau publications.

Even with the annual expenditure of this sum, it will require a considerable period to study the many kinds and problems of electroplating. More rapid progress could no doubt be made if additional funds were available. If, therefore, the platers or manufacturers interested in electroplating desire to contribute to the support of this work, preferably through the American Electroplaters' Society, satisfactory arrangements can no doubt be made. Such support might either take the form of annual subscriptions from firms, or of the employment by firms themselves of persons to work at and under the direction of the Bureau of Standards upon some problem of general interest. In the latter case the facilities of the Bureau could be employed with the understanding that all the results of such work would be made available to the public.

In order to make this work of value to the industry, it is important that in the future, as in the past, we should receive the active support and assistance of the electroplaters, who are, therefore, encouraged to send to the Bureau information possessed by them, and requests for information desired by them.

Bureau of Standards, Washington, D. C. S. W. STRATTON, Director.

Decomposition of Metals

To the Editor of Chemical & Metallurgical Engineering

SIR:—In my article on "Decomposition of Metals" in your issue of April 15, 1919, there was an error on page 423, first column, first line. The last part of the sentence should read: "we might expect a transformation of β crystals into brittle γ crystals to occur in certain brasses under certain conditions." The sentence as printed had α crystals instead of γ crystals.

Bureau of Standards, Washington, D. C. A. I. KRYNITZKY.

The Oxidation of Ammonia

AT THE May 8 meeting of the Washington Section of the American Chemical Society Dr. Charles L. Parsons presented an interesting paper on the oxidation of ammonia. A brief résumé was first given of European work along this line including a description of the Ostwald process and of the Frank-Caro process. The Ostwald process was first put into commercial operation at Gerthe, Westphalia, in 1909, and later at Vilvorde, Belgium. During the war plants using this process were operated at Angonleme, France, and Dagenham, England. After the beginning of the war in 1914 the Frank-Caro process was developed by the cyanamide interests of Germany and this process was used in the huge German plants later built. It is a matter of surprise that there appeared in the January, 1916, issue of *Metall und Erz* a detailed description of the Frank-Caro process as then developed.

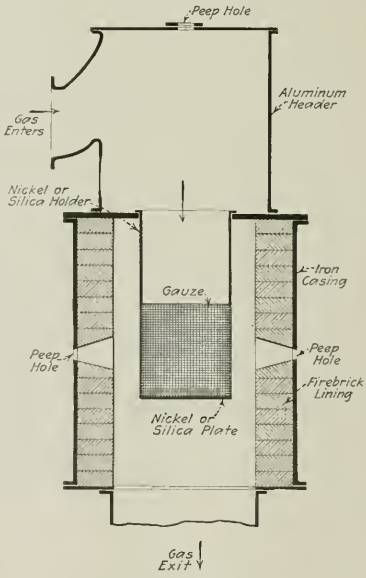
The Frank-Caro apparatus used a flat platinum gauze as a catalyst to promote the reaction in the air-ammonia mixture. The American prototype of this flat gauze converter is the Landis converter of the American Cyanamid Co., first used at Niagara Falls early in 1916, later at Warner's, N. J., and finally installed in the large U. S. Nitrate Plant No. 2 at Muscle Shoals, Ala. The installation at Muscle Shoals has been described by Fairlie in CHEMICAL & METALLURGICAL ENGINEERING, Vol. 20, No. 1, page 8, Jan. 1, 1919.

In August, 1916, the Bureau of Mines entered into a co-operative investigation of ammonia oxidation with the Semet-Solvay Co. Under this arrangement there was put into operation several months later, at the Semet-Solvay's plant near Syracuse, N. Y., a converter of the Landis type using a flat platinum gauze approximately 1 x 2 ft. as a catalyst. The primary purpose of this installation was to determine whether by-product coke-oven ammonia could be oxidized readily by means of such a converter. The apparatus worked well, running on the Semet-Solvay "Grade A" by-product ammonia with high efficiency. The consumption of electrical power for heating the gauze was, however, considerable, and appeared unnecessary in view of the large amount of heat liberated by the oxidation reaction itself. The design of a converter in which the heat developed by the reaction should be utilized to maintain the necessary gauze temperature was therefore undertaken.

It had been noted that the flat gauze converter would operate without electrical heating on a 10 to 12 per cent ammonia-air mixture, but with a lowered efficiency, due apparently to too low a gauze temperature. By simply using three layers of previously activated gauze it was found that fairly high efficiencies would be reached without electrical heating. It appeared, however, that the gauze temperature was still somewhat too low. Attention was then turned to a new design of apparatus in which the previously activated gauze was rolled into a cylinder and supported concentrically in a brick-lined cylindrical casing. One end of the gauze cylinder was closed with a quartz or nickel plate. The air-ammonia mixture was forced in at the other end of the gauze cylinder and passed out through the four layers of gauze forming the cylinder wall. By this arrangement the heat generated by the reaction was conserved to such a degree that a satisfactory operating temperature was maintained in the gauze.

The air-ammonia mixture, containing about 10 per cent of ammonia, is delivered at the top of the converter through an aluminium pipe. The reaction is initiated at the gauze by projecting a small flame against it for a moment until the oxidation reaction starts. The glow soon spreads over the whole gauze. The hot gases leaving the gauze impinge on the brick lining of the outer casing and bring this up to near red heat, so that considerable heat is radiated back onto the gauze. After being put into operation the apparatus requires no further attention. A converter of this type was operated continuously at the Semet-Solvay's plant from February to September, 1918. It was shut down on the latter date only because an inexperienced plant operator allowed caustic solution to back up into it. On a 23-day test run with one of these converters at Syracuse in 1918, an average of 160 efficiency determinations gave 90.7 per cent.

The platinum gauze used is woven of 0.0026-in. diam. wire, 80-mesh per linear inch, and weighs approximately 16½ ounces. The converter is operated with a gas flow of 200 cu.ft. per minute, representing a capacity of about 2½ tons of nitric acid (figured as 100 per cent acid) per day. The gauze must be kept free from iron oxide, oil and the like. Impurities in the gas, such as the phosphine in cyanamide ammonia, or



CATALYTIC CONVERTER

the organic impurities in Grade B by-product ammonia, lower the oxidation efficiency of the converter. It is now known, however, that phosphine can be removed from cyanamide ammonia, either by making aqua ammonia under certain conditions or by passing the gas through a bed of gas-mask charcoal. Also it is known that most of the phosphine can be removed by blowing air through the autoclaves for a short time before the cyanamide is steamed. Since impurities in the ammonia gas lower the gauze temperature, it is evident that either preheating the gas by means of the waste heat

of the reaction or adding electrical heat to the gauze will result in higher efficiency when oxidizing an impure ammonia. The converter operates normally at about 825 deg. on a 10 to 11 per cent ammonia-air mixture. In general the oxidation efficiency at a given gauze temperature is inversely proportional to the percentage of ammonia, but the cylindrical gauze converter will not operate well with much less than 10 per cent ammonia in the gas mix unless a preheater is used. In preheating the air-ammonia mix, the preheater must be so designed that only nickel, aluminium or silicate parts are in contact with the hot gas, for other material decomposes the ammonia.

The cylindrical gauze converter as developed by the Bureau of Mines was slightly modified by the Ordnance Department and installed in U. S. Nitrate Plant No. 1. The results obtained with the converter at this plant, being Ordnance Dept. records, Dr. Parsons was, unfortunately, not at liberty to discuss.

As the last item in his paper Dr. Parsons presented a graph showing the cost of producing nitric acid from Chile nitrate as compared with its production by the oxidation of ammonia and subsequent conversion of the nitrogen oxides to nitric acid of various concentrations. The interesting point was made that, on the basis of the estimates represented, a 94 per cent nitric acid could be made by the ammonia oxidation process (with subsequent concentration) in competition with nitric acid from Chile nitrate when the price of Chile nitrate was 2c. per lb. and cost of producing ammonia 11½c. per lb.; likewise the cost of 50 per cent nitric acid would be the same from the two processes when Chile nitrate cost 2c. per lb. and ammonia 14c. per pound.

Modern Training of the Chemical Engineer

AT A meeting held at the College of the City of New York under the auspices of the College Chemical Society, April 25, Dr. Ralph H. McKee. professor of chemical engineering of Columbia University, presented a paper dealing with certain phases of chemical engineering education, particularly with recent changes in the curriculum.

We may define the scope of a chemical engineer's work by saying that he applies knowledge obtained from the field of pure science and from the field of engineering to the solution of the problems of applied chemistry. Due consideration must be given to the financial element, so that the solution may be commercially practicable.

A process must go through several stages before it becomes a part of chemical industry. After leaving the laboratory, the process is developed in a small-scale plant. If successful, a full-sized plant is next constructed and operated by partially skilled labor, after having been trained by the technical staff. Following the initial operating period, refinements in the process are made by the chemical engineer.

Some fifteen years ago, when chemical engineering was in its infancy, there was considerable discussion as to whether the training of a chemical engineer should be primarily along engineering lines and only secondarily chemical, or vice versa. A number of the larger universities took the former attitude, but at the present time it is conceded that the emphasis should be placed upon the chemical training. It is essential that the instructors should be familiar with actual practice and should not have to rely on text-books. It has been said that text-books of industrial chemistry are mostly descriptions of methods that are obsolete. This statement was made twenty years ago, but it is even more true today. The Chemical Warfare Service took on an average three months to develop a new process and by that time the process was often obsolete. Of course, this work was done under the stress of war-time necessity, but it is, nevertheless, an indication of the changes which are constantly taking place in the industry.

In industries of a mechanical nature, production costs may be distributed approximately as follows: Labor, 35 per cent; materials, 35 per cent; overhead, 30 per cent; while for a chemical plant the cost of labor may vary from 12 per cent to as low as 1 per cent; materials, up to 90 per cent; overhead, in some cases 30 to 35 per cent. It is evident that in the chemical industries, efficiency of operation and maximum output are the main factors governing cost of production. A 3 per cent increase in yield may be equivalent to cutting the labor cost in two.

While the cost of labor is not a major item. labor itself is exceedingly important. The technical force should be well paid and the laborers should be fairly intelligent, as carelessness on their part may result in large losses of valuable materials. Carefulness and willingness of workmen to follow instructions are more important than education. It is interesting to note the possibilities which may result from the employment of psychological tests, such as have been used in the United States Army, in the selection of labor.

Twenty years ago, the chemical engineer studied general chemistry, qualitative and quantitative analysis (including assaying) and text-book work only in metallurgy, organic and industrial chemistry. Ten years ago, physical and electro-chemistry were added to the list, emphasis being placed upon the theoretical treatment of these subjects. At the present time the tendency is to increase the time devoted to laboratory work in the general, organic, physical, electrochemical and industrial chemistry courses, and to cut down the work in qualitative and quantitative analysis, metallurgy and the classroom work in physical chemistry. Assaying is generally omitted. During this same period, in connection with the other college courses, there has been a decrease in the amount of drawing and mechanical engineering required, and civil engineering has been largely eliminated. In their place we find heavier courses in physics, a study of business law, contracts, specifications, etc., and certain phases of biology, such as the utilization of bacteria, yeasts and molds which are capable of producing chemical transformations.

Since there are different requirements for chemical engineers, there should be different kinds of chemical engineers. With this object in view, the present graduate courses in chemical engineering at Columbia University have been chosen primarily for the purpose of training men who may become superintendents and managers of plants, and less for work in industrial research laboratories. The phases of the work given at Columbia but not customarily given in undergraduate curricula of chemical engineering are the following:

1. Chemical factory machinery, including plant construction and apparatus layout.
2. Applied colloid chemistry.
3. Factory wastes disposal.
4. Plant management, including problems relating to

labor, insurance, laws governing dangers, compensation, etc.
5. Efficiency engineering.
6. Laboratory courses using standard semi-factory size equipment.
7. One summer vacation period of eight weeks must be spent by the student in a factory as a laborer in order that he may be able to understand the workman's point of view.
8. In the third year, the student takes up a research problem of a factory type.

So far as I know no university teaches its engineering students the handling of labor and employment. The indications are that these subjects may be satisfactorily taught in the class-room. We at Columbia are trying to work out a method of handling these subjects but we have not yet quite reached the stage where we are ready to offer such courses to our chemical engineering students. Army experience has shown the value of psychological tests, and experiments in scientific labor employment in several factories have proved successful. In one plant employing 6000 persons, it was found necessary to hire 15,000 in 1917, so that the labor turnover was 2½. After the introduction of psychological tests, a report showed that the excess labor amounted to only 3000 per annum, or a labor turnover of 1½. Since it costs from $75 to $300 to break in a new man, depending upon the nature of the work, the importance of reducing labor turnover to a minimum is apparent.

American Scientific Glass

AT the meeting of the New York section of the American Chemical Society, May 9, a symposium on Scientific Glass was held. Harrison E. Howe of A. D. Little, Inc., read the leading paper, in which he reviewed the developments beginning with the work of Fraunhofer, Faraday and Harcourt and through the classical researches of Ernst Abbe and O. Schott at Jena. Since an account has recently been published[1] covering similar ground, only brief mention will be made of some of the new features brought out.

The plate glass slab rolling method has been successfully applied, which facilitates grinding and selection of suitable lens pieces. Motor-driven stirring apparatus has been adopted in place of hand stirring. It is necessary to have sand with less than $\frac{1}{200}$ per cent iron content. Phosgene treatment costs $40 per ton and only removes the iron not sealed in the silica aggregates. The maximum limits of constituents are as follows:

	Per Cent.		Per Cent.
Silica	75	Baryta	50
Alkali	20	Zinc	12
Lime	15	Alumina	5
Lead	7	Boron	20

Dr. A. V. Bleiniger of the Bureau of Standards pointed out the future needs of the industry as being purer raw materials; better data, as there are many gaps in the present curves; a knowledge of annealing theory and a set of optical specifications. The glass pots developed by the Bureau are made of a mixture of open and dense burning clays obtained from Tennessee, Kentucky and Georgia. The resistance of the pot to slagging is due primarily to the closed dense surface of the pots giving a minimum area of reaction contact. Large ton pots are necessary in order to get the ratio of glass volume to pot contact reduced small enough to keep the slagged impurities concentration low enough.

Carl W. Keuffel stated that counter colors or bleaches could not be used because of the resistance to light transmission they set up in the glass. After last September more than adequate supplies of good glass were available—the glass manufacturers passed the instrument makers in the race.

Mr. Harry Rosenthal spoke of the recent celluloid-glass lenses which are not shatterable with a 2-ft.-lb. blow. Color absorbing, and matching glasses are readily made by dyeing the celluloid.

[1]Home-made Optical Glass, H. E. Howe, CHEM. & MET. ENG., Sept. 27, Vol. 19, No. 6d., Page 479.

American Institute of Chemical Engineers, Boston Meeting

THE eleventh semi-annual meeting of the American Institute of Chemical Engineers will be held in Boston, Mass., with headquarters at Lenox Hotel, from June 18 to 21, 1919. Following is the official program:

Wednesday, June 18, 1919.
- 9:00 A.M. Registration at Engineers' Club.
- 9:30 A.M. Welcome by the Mayor or his representative and response.
  Business session.
- 10:00 A.M. Reading of papers:
  Symposium on Electric Furnaces.
  The Future of the Electric Furnace, C. T. Bragg, Mich. Smelt. & Ref. Co.
  Utilization of Electric Brass Furnaces, H. W. Gillette, Bureau of Mines.
  Problems Encountered in Electric Furnace Practice, P. E. McKinney, Washington Navy Yard.
  Electric Furnaces of the Resistance Type—Ill. by motion pictures, T. F. Bailey, Electric Furnace Co.
- 12:30 P.M. Luncheon at Engineers' Club.
- 2:30 P.M. Reading of papers:
  Symposium on Electric Furnaces continued.
  Ajax Wyatt Induction Furnace—Slides, G. H. Clamer, Ajax Metal Company.
  Some Practical Results Secured with High-Frequency Induction Furnaces, Dr. E. F. Northrup.
  Booth-Hall Rotating Furnace—motion pictures, Carl H. Booth, Booth-Hall Co.
  The Rocking Electric Arc Furnace, E. L. Crosby, Detroit Elec. Furnace Co.
- 8:00 P.M. Smoker in assembly room, Arthur D. Little, Inc., with inspection of museum and laboratories. The paper mill will be in operation, and arrangements made for special laboratory demonstrations.

Thursday, June 19.
- 9:30 A.M. Board tug for tour of inspection of industrial plants along Boston waterfront, Commonwealth and Fish piers, the largest fish-handling pier in the world.
  Victory shipbuilding plant at Squantum.
  Revere Sugar Refinery.
  Buffet lunch, on tug.
- Afternoon—Edison Power Plant.
  New England Gas & Coke Co.
  Trip by tug to Marblehead.
  Dinner at Eastern Yacht Club.
  Return to Boston by tug, train or auto.

Friday, June 20.
Meeting at Mass. Inst. of Technology.
- 9:00 A.M. Business meeting.
- 10:00 A.M. Reading of papers:
  Growth and Development of the Manufacturing Plant of the Providence Gas Co., W. H. Russell.
  Flash and Burning Points of Gasoline-Kerosene Mixtures, James T. Robson and James R. Withrow.

Chemists Should Be Registered and Licensed, Edward Gudeman.
State Licensing of Engineers and Chemists, James R. Withrow.
Chemists Should Not Be Licensed, A. W. Smith.

12:30 P.M. Luncheon at Walker Memorial, M. I. T.

1:30 P.M. Inspection of laboratories, Mass. Inst. of Technology.
Harvard University, including the Peabody Museum, the Wolcott Gibbs Laboratory of Research Chemistry, and the Jefferson Laboratory of Physical Research.
The Agassiz Museum, The Glass Flower Exhibit, will be open.

4:30 P.M. Historic Boston by sightseeing auto.

7:00 P.M. Dinner at Brookline Country Club.

Saturday, June 21.
All day excursion by train to Lawrence, Mass., for inspection of plants—Champion International Co. (paper) and some of the largest textile plants in the world, as Pacific Mills, Arlington Mills, American Woolen Co.
Return to Boston by train.

Surplus Government Supplies

Sodium nitrate will be sold for the War Department by W. R. Grace Co., Wessell, Duval & Co., and H. B. Baker Co. of New York City and the Du Pont Nitrate Co. of Wilmington, Del.

Sulphur will be sold by the Union Sulphur Co., New York City.

Copper will be sold by the United Metals Selling Co., New York City.

Alcohol will be disposed of, as far as possible, by supplying the needs of the other departments of the Government. Any surplus remaining after all of the bureaus have been amply provided for will be sold back to the producers.

Spring Meeting of the T. A. P. P. I.

The Association will convene Wednesday morning, June 11, at the Hotel Lawrence, Erie, Pa., for inspection trips to the plants of the General Electric Co. and the Hammermill Paper Co. Following a complimentary dinner by the latter company, the Association will leave Erie for Buffalo, where business and technical sessions will be held in the auditorium of the Larkin Co. Paper and pulp manufacturers on both sides of Niagara Falls have offered to open their plants for inspection. Details of these visits will be announced later. Henry F. Obermanns, Hammermill Paper Co., Erie, Pa., and Paul Kellogg, Larkin Co., Buffalo, N. Y., should be notified of the intention to attend.

Chicago Meeting A. I. M. E.

The American Institute of Mining and Metallurgical Engineers will hold its Fall meeting in Chicago, Sept. 22 to 26. This meeting promises to be one of decided importance to the industry, as subjects of vital concern will be under discussion. In addition to the technical talks, an elaborate social programme is being arranged, and excursions by the Institute as a body are planned to many points of interest in the vicinity, including the steel mills at Gary, the oil refineries at Whiting, metallurgical plants at East Chicago and North Chicago, and to the LaSalle district, where the cement, coal and zinc industries are represented.

Industrial and Academic Co-operation

THE much heralded co-operation between industry and technical schools is rapidly becoming a fact. Good evidence of this was shown in Brooklyn at the annual dinner of the Polytechnic Institute Alumni Association and the Chemical and Engineering Societies on May 10. Dr. John C. Olsen was toastmaster and had a complete stock of wit on tap which compensated for the way the wine and Scotch was served, in cubes. Dr. F. W. Atkinson reviewed the progress of the institution, which has grown to 800 students. Eighty thousand dollars was received in donations during the past year, of which $35,000 was subscribed by Dr. William H. Beckers, vice-president of the National Aniline Co., for use in the chemical engineering laboratory. When Dr. Beckers was asked to tell how he managed to build up the large Beckers dye works in the face of German competition before the war, he said that independent American manufacturers could not use imported intermediates very well. His chief product was a blue dye resembling anthracene blue, but actually made of gallic extract and cymene. It was not a fast dye and the Germans quickly persuaded the trade to abandon it by demonstrating the comparative fastness of their anthracene, which was about forty times more fast. However, Dr. Beckers ultimately found out that his dye was good for four seasons' wear and so was able to get and hold onto a fair trade. Dr. Beckers' advice to the chemical alumni was to pick out one or two propositions and persistently stick to them until they were accomplished. To those who had been successful in business he said, "It is not enough that the wealthy trustees give their hundreds or thousands of thousands of dollars in endowments. They must co-operate in their technical work with the technical schools. Ample rewards should be liberally given for results accomplished.

Lt.-Col. Alfred H. White briefly outlined the operations at Muscle Shoals and had most excellent slides shown on the screen. Dr. Frederick de Jahn of the General Chemical Co. was called upon to tell about the G. C. process but preferred to say no more than that they were very successful. The finale was ingeniously worked out by Dr. Irving W. Fay. A large Old Glory was developed by blowing some of the G. C. synthetic ammonia on its once-believed-to-be-all-white-banner-by-the-über-alles-dye-makers-of-the-Rhine and true to form, the colors gleamed forth amid the closing song by the alumni of "The Star-Spangled Banner."

Exchange of American-Scandinavian Scholarships

The American-Scandinavian Foundation announces the establishment of 10 new scholarships beginning with the academic year 1919-1920 for young American scientific students who desire to complete their study and research in Sweden. Each scholarship will provide $1,000 for one year's study and the funds will be provided by Americans who desire to promote interchange of knowledge between the two countries. Similarly, funds are being raised in Sweden to send 10 Swedish students to the United States. Physics, chemistry, hydro-electric engineering and metallurgy are among the subjects offered. Applications will be acted upon by a committee and should be filed before June 1. Papers can be secured from the American-Scandinavian Foundation, 25 West 45th St., New York City.

Photography in Research

A Concise Review of the Applications of Photography in Industry—Illumination, Lenses and Appliances—Motion Microphotographs Record Stresses in Wrought Iron—Opportunities for Development

By ARTHUR G. ELDREDGE

INDUSTRIAL organizations and educational institutions have for some time recognized the value of photography, its chief uses being for records, graphic proof on progress of work, or illustrations for lectures. Investigators would do well to follow in such footsteps, since in science there is absolutely no other means of adequately recording the facts. Words fail completely to portray conditions. Drawings can but poorly convey the texture, minute detail or substance of an object as it really is. Photography does swiftly, accurately and easily these things which by other means are done laboriously or not at all.

Modifications of the simple camera have a limit to their accomplishments. The next step is the microscope. What remarkable things it does for us! On the other side of the eyepiece there awaits a new world, things indescribable, impossible of delineation. Photography steps in, it accentuates color contrasts or eliminates them, it will record the facts for which you seek if used with skill. In the living sciences it reveals for the masses those secrets with which few are acquainted. In mineralogy it shows by polarized light rock structures we could not have guessed. (Figs. 1 and 2.) Modern metallurgical methods and products could hardly exist but for information revealed by the microscope. In this case photography can record the facts of structure and composition for quick comparison.

Surpassing all of these methods is the motion picture. In this instrument we have a tool outstripping the magic of Aladdin. It tells things we would not dare dream. It may prove beyond contradiction things beyond the wildest conjecture. Our eyes are something of a compensating instrument—they can interpret only slow motions, and by reason of the persistence of vision are a complete failure in splitting seconds. Not so the motion picture; with it consecutive pictures of a moving object may be made with exposures varying from one-fifth of a second to one ten-millionth of a second. Pictures taken at excessive speeds when projected at the normal rate of 16 exposures per second permit one to analyze the motions and to understand things entirely beyond ordinary vision.

In the field of research men are endeavoring to uncover the unknown, to do the "impossible," but are far too slow in adopting photographic methods. The moving picture and the microscope can see a million times quicker and smaller than the eyes. Unaided vision can recognize a two-hundredth of an inch, but not interpret it, while motions quicker than a tenth of a second run together: one cannot separate them. How, but for the microscope and photography, could we know the vast world beyond? It can show what is happening right down to the bare bones of matter and force.

Limitations of Optical Lenses

Many who read this may not be thoroughly familiar with the optics of an optical or photographic microscope, so some of the principles affecting this work will be noted briefly. In applying photography to the microscope we find certain exacting conditions and narrow limits in which to work; the laws governing numerical aperture, resolving power and wave length are inflexible.

In working with opaque objects the problem is much

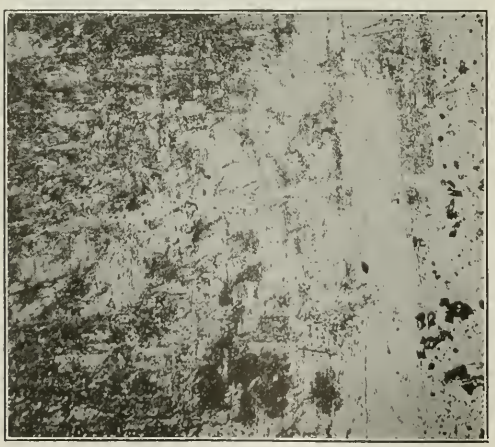


FIG. 1. FELDSPAR BY ORDINARY LIGHT. × 100
IDENTICAL AREA AS IN FIG. 2

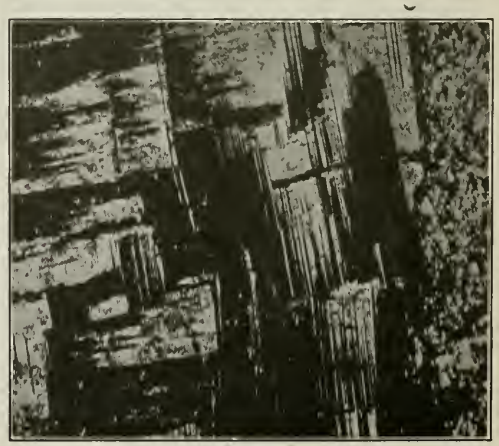


FIG. 2. FELDSPAR BY POLARIZED LIGHT, CROSSED NICHOLS. × 100

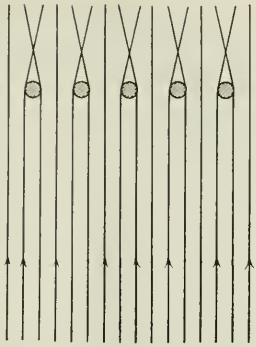


FIG. 3. EFFECT OF DIFFRACTION ON PARALLEL LIGHT

different than with transparent objects. In the latter case the illuminating system passes the light rays directly through the specimen and into the miscroscope. The resolution of the system, or the power to render visible the various parts of the object, is an important consideration, as well as the thickness and quality of specimen, glass slide and cover glass. In low power work we are able to make full use of the resolving power of the lens and it is comparatively easy to obtain

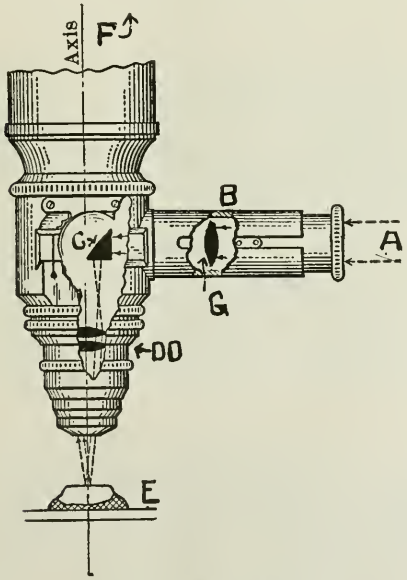


FIG. 4. PRISM ILLUMINATOR

perfect results. As we understand it, resolution may be defined as the ability of an objective to render correctly the diffraction phenomena of a subject in transmitted light. If we place a rod in a stream of water the water flows around it. If we place a rod in a beam of light some of the rays no longer travel straight but bend around the edges of the obstruction—this we call diffraction. Such opaque lines in a subject may be several thousand per inch, when the diffraction image will be confusing and if not correctly rendered will lead to misinterpretation. (Fig. 3.)

In the case of opaque objects reflected light is used, the objective acting both as condenser and objective. At first sight it appears quite impossible that the objective can transmit light in one direction to illuminate a subject and transmit in the opposite direction the image of an object so illuminated without interference. Yet in this case one is concerned mostly with

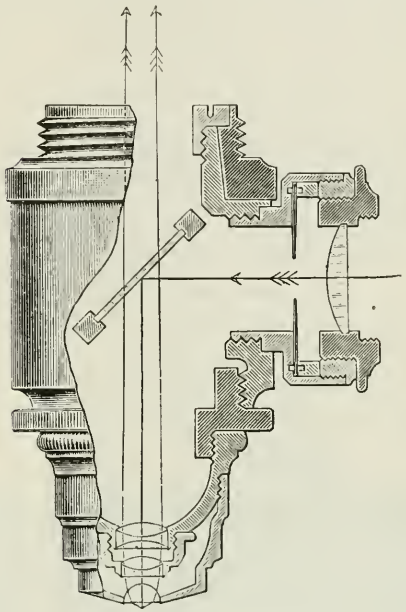
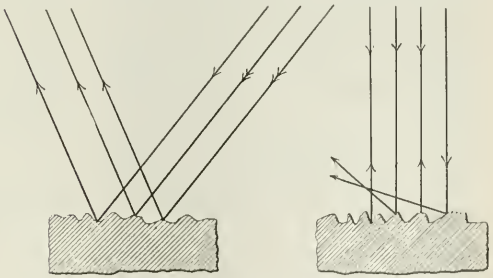


FIG. 5. PLANE GLASS REFLECTOR

the defining power of the lens, rather than its resolution.

There is another important qualification for the microscope lenses—their correction for color. The ordinary microscope has achromatic lenses, that is to say, they are corrected for two regions of the spectrum so that there is little trouble with color fringes at low powers. A superior system of lenses is called apochromatic; these bring the three regions—red, green and blue—to a perfect focus with the image by the use of lenses of different kinds of glass, so that there are



FIGS. 6 AND 7. AT LEFT—OBLIQUE LIGHT RENDERS THE SUBJECT DARK WITH FEW BRIGHT LIGHTS, ALTERING THE APPEARANCE OF THE RELIEF. AT RIGHT—VERTICAL ILLUMINATION RENDERS BLACKS AS BLACK AND POLISHED SURFACES LIGHT

no color fringes. In using the microscope for ocular observation, color fringes, defects due to spherical aberration and lack of definition are not always serious defects, because the eye is something of a compensator and has "persistence of vision." In photography, color fringes destroy the sharpness of the image, while spherical aberration, producing different foci for central and marginal rays, permits only a portion of the subject to be clearly defined on one exposure, so the results may be not only unintelligible but misleading. The plate has no imagination, it records the facts as presented.

Illumination of Opaque Objects

To illuminate an opaque object such as a piece of polished metal, a vertical illuminator furnishes the only correct rendering, but its use does impair the optical qualities of the objective. In the customary objective for transmitted light, the lenses are mounted at varying distances by different makers, and corrected

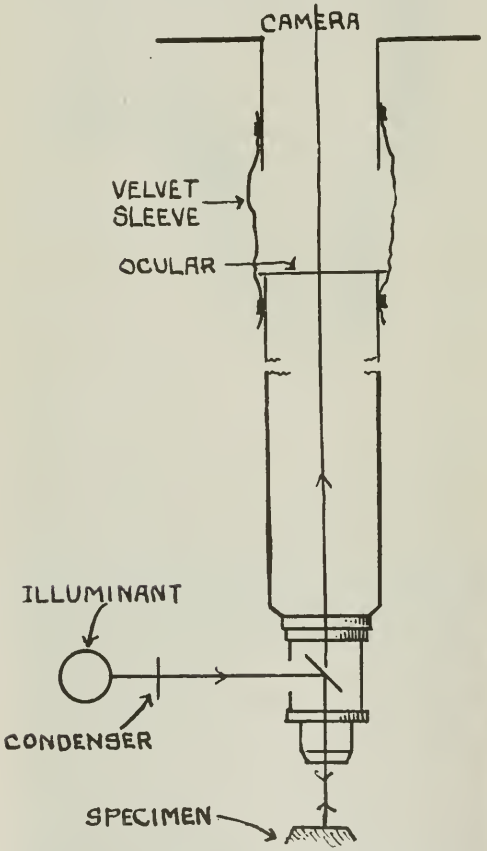


FIG. 8. ARRANGEMENT OF APPARATUS FOR MAKING MOTION PHOTO MICROGRAPHS OF OPAQUE OBJECTS

for a cover glass over the specimen. For use with the vertical illuminator the lenses must be short mounted to avoid internal reflections and uncorrected for cover glass—none being necessary.

Figs. 4 and 5 illustrate two common types of vertical

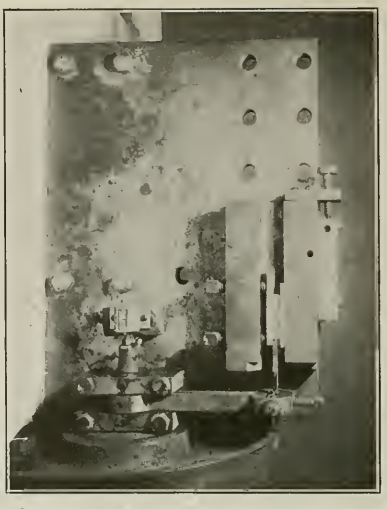


FIG. 9. STRESSING MACHINE DESIGNED BY PROF. H. F. MOORE, WITH TEST SPECIMEN IN PLACE. ROTATION OF FLYWHEEL TRANSMITS VERTICAL OSCILLATION TO THE OTHER END OF THE TEST PIECE, PRODUCING BENDING AT THE VISE

illuminators. With the plane glass reflector there is a tendency to produce a haze over the image, while with the prism there is a tendency to form a sculptured or relief image. Yet either gives satisfactory results under proper conditions.

From the illustration (Fig. 4) it is seen that the illuminant at *A* passes its light into the tube *B* (preferably in parallel rays) through the converging lens *G* which focuses the light source on the hypotenuse of the prism *C*, thence through the objective lenses *DD* which concentrate the light on the subject *E*. An image of *E* is formed by *DD* projecting it to the ocular *F* which not only magnifies the image but corrects errors of the objective.

Such illumination does not appear to be a difficult operation, yet under some conditions trying difficulties occur. For instance, it is essential that *AB* be at right angles to the microscope tube and that the lenses be clean and free from dust. (It seems quite impossible to keep dust from the lenses; it returns again and again.) The axis must be perpendicular to *E*, otherwise

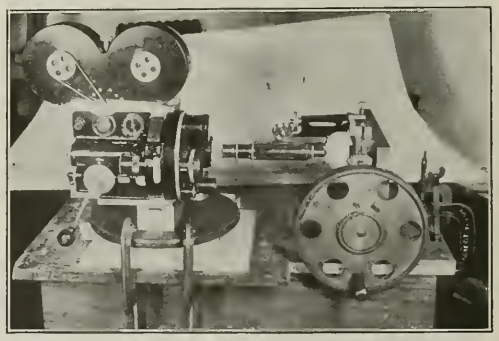


FIG. 10. ASSEMBLED APPARATUS WITHOUT VELVET SLEEVE OR ILLUMINATING DEVICE

the specimen will not appear properly illuminated. It is seen in Fig. 6 that if the light is at all oblique the reflected rays which should pass into the objective will fall outside. The relief will be changed in appearance and the object will appear but partly lighted. In Fig. 7 the light falls vertically, most of it returns to the objective and the relief appears correctly.

Illumination for Motion Picture Camera

To make motion pictures through this apparatus it is necessary to place a motion picture camera at a short distance from the ocular *F*, as shown in Fig. 8. The lenses are preferably removed, while magnification is changed by using oculars of various powers.

For motion work of this nature a flickerless light-source is necessary, as any fluctuations in illumination are recorded in the negative. The axes of light-source and of microscope must be at right angles horizontally and vertically, and the surface of the film must be at right angles to the axis of the microscope. Furthermore, all of the elements must be rigidly fixed. To comply with these conditions in a built-up apparatus requires considerable time and care. As a case at hand, some motion pictures of a wrought-iron test bar showing the mechanism of failure under alternating stresses were made for Prof. H. F. Moore of the Materials Testing Laboratory, University of Illinois, the designer of the fatigue machine (Fig. 9). I used a 400-watt gas-filled lamp of stereopticon type, the image of one filament only being employed, which was projected into the tube by the condensers of a No. 0 delineascope. An arc was found to be not only too intense but too variable in color and position. A gas-filled bulb with only one filament would be very desirable, while the Nernst or the new incandescent lamp as used for motion picture projection might answer well. It is best to absorb the heat from the light with a water cell. A prism illuminator was used with an achromatic objective and a compensating ocular, as these oculars give much better results than a Huyghenian.

Motion Microphotographs

All types of motion cameras are not readily adaptable to these special problems. Devices have been constructed for making motion pictures in various lines of research, notably at the Marey Institute in France. For my purpose I found the Bell and Howell camera an incomparable instrument. It is entirely of metal, compact and mechanically faultless. The rotating lens turret and the sliding base permit the focusing aperture to be moved to the exact position occupied by the film when recording.

As shown in Fig. 10, the camera and the stressing machine are clamped very firmly to a substantial table—a masonry pier would be more desirable—and the camera is then connected to the microscope by a black velvet sleeve to facilitate adjustments and to break the transmission of any vibration. A device for observing the action continuously by eye might be inserted but would result in some loss of definition. The microscope

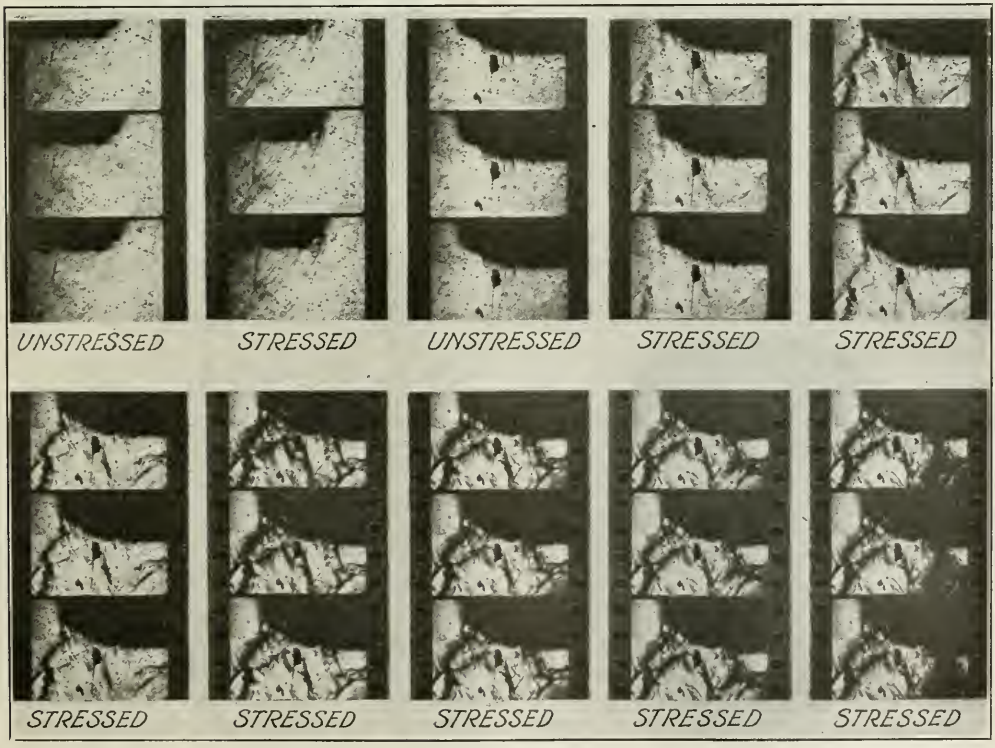


FIG. 11. MOTION PICTURES THROUGH THE MICROSCOPE. SUCCESSIVE STAGES IN REPEATED STRESS OF WROUGHT IRON. × 70

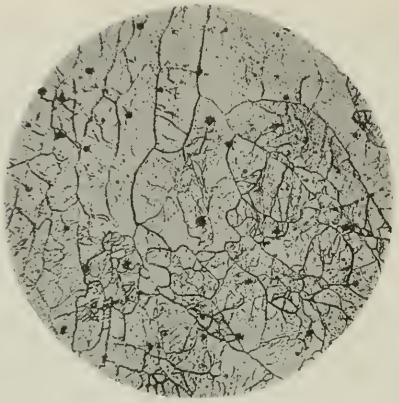


FIG. 12. STRUCTURE OF WROUGHT IRON BEFORE BEING SUBJECTED TO REPEATED BENDING STRESSES. × 200

was first focused on a polished region at the base of the shoulder, shown in Fig. 9, where the stresses will be most intense.

Photographs of metals are usually at low power—one hundred or less. In making motion pictures the magnification was even lower in order to exhibit a sufficient field for study. This leads to more difficulty, because in the low magnification, the lines made by the crystal boundaries become so narrow that it is difficult to retain them in negative and positive with enough density to project well. It is possible to improve the sharpness of the image by using deep colored screens, preferably in the blue-green, thus eliminating other colors which might form color fringes. If this is done. panchromatic film is necessary. By the accompanying table of resolving powers for transmitted light it is seen how much the working qualities of lenses are improved by increasing the numerical aperture and decreasing the wave length. Violet light is difficult to use, however, because the eye works very poorly in that region and it is quite impossible to focus the object, even with a magnifier. Sections of the film made in the present instance are shown in Fig. 11, while exposures of the same test made at higher powers with an ordinary metallographic microscope are shown for comparison in Figs. 12, 13 and 14. In the results shown here the negative was made on positive film at the normal speed of 16 pictures per second, giving an exposure of $\frac{1}{48}$ of a second, the negative film being too fast and not giving satisfactory contrast.

LIMITING RESOLUTION

Objective	N.A.	Yellow line D λ = 5896 A.U.	Green line E λ = 5269 A.U.	Violet line H_γ λ = 4341 A.U.
1½	.10	8,617	9,641	11,699
¾	.25	21,542	24,103	29,247
⅓	.6	51,700	57,846	70,193
⅛	.9	77,550	86,769	105,289
Oil immersion 1/12	1.4	120,638	134,974	163,783

The little work which I have done in this field and the consideration of other special problems lead me to think that the motion camera with and without the microscope offers a means of research the value of which we can hardly predict. The field of application is as wide as human knowledge. Processes and reactions in the natural sciences and phenomena in the physical sciences will unfold many opportunities as we search for new facts. Special apparatus has been constructed whereby consecutive exposures can be made, each in one ten-millionth of a second. With such a tool, the transmission and reaction of sound waves might be quite readily photographed in motion.

One day some one may record the passage of electrons discharged across a vacuum. We can hardly set a limit.

University of Illinois.
Urbana, Ill.

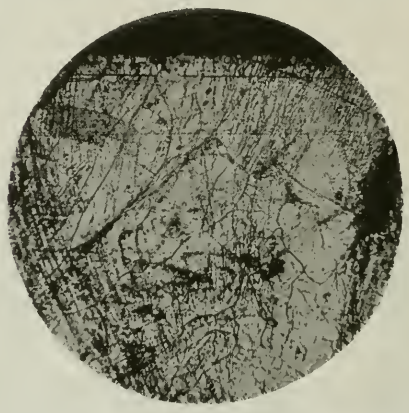


FIG. 14. WROUGHT IRON AFTER REPEATED BENDING STRESS. × 200. THE FINE LINES ARE "SLIP LINES" DEVELOPING ACROSS THE CRYSTALS

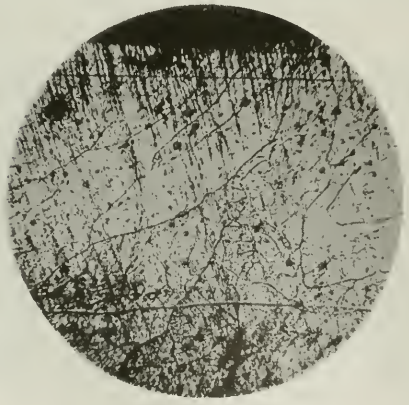


FIG. 13. SLIP LINES DEVELOPING ACROSS THE CRYSTALS. × 300

Where Hamlet Was

Referring to our notes under the title of "'Hamlet' with Hamlet Left Out," in our last issue, Major Charles E. Sholes, honorary chairman of the N. Y. Section of the Society of Chemical Industry, calls attention to the fact that it was not the fault of the authors that the paper on Fuels was missing. The manuscript had been mailed in ample time and was *en route*, where it rested for a considerable period along with the information that the authors, Messrs. Bacon and Hamor, were prevented by pressure of other duties from putting in personal appearance. It will appear in an early number of the Journal of the Society.

An Improved Method of Optical Glass Manufacture*

By George W. Morey

THE USUAL practice in the manufacture of optical glass consists of the following sequence of furnace operations:

The pot is carefully preheated in a small subsidiary furnace, called a pot arch; from there it is "set," or transferred to the furnace. The pot is usually set at a temperature of about 1050 deg. C., and it must be heated up to the melting temperature of the glass batch, about 1400 deg. for most glasses, before filling. The best practice is to overburn the pot before commencing the fill.

The batch, or batch mixed with cullet, is fed into the pot in several installments, until the fill is complete. The details of this process differ from plant to plant.

After the fill is complete, the glass is left undisturbed for several hours, primarily to give time for the bubbles to rise to the surface. The temperature during this period is high; in some places it is the practice to use a higher temperature for the fining operation than for the fill.

After the fining period is complete, it is customary to stir the glass by hand, intermittently; a common schedule is to hand stir for 15 minutes every two hours. This process removes the bubbles of gas adhering to the side and bottom of the pot, and helps to secure uniformity in composition.

After the period of intermittent hand stirring is complete, the glass is stirred continuously, a stirring machine being used. As a rule, soon after putting on the machine, the fire is turned off and the glass allowed to cool, stirring being continued until the pot is removed from the furnace. The operations summarized above take from two to three days in the furnace, the actual time depending on local practice. When, as is usually the case, the empty pots are preheated in pot arches, and the finish glass cooled in an appropriate subsidiary apparatus, a melting furnace will yield one pot of glass every two days.

New Schedule Doubled Production

After considerable experience in manufacturing optical glass, certain of the usual operations seemed to be inadequate or illogical, and soon after taking charge of the optical glass plant of the Spencer Lens Co. for the War Industries Board, I devised a new schedule radically different from the above, which may be called the "24-hour" process. Because of its importance in practically doubling the production of optical glass, a basic material in the manufacture of fire control instruments, the details of the process were communicated to the Military Optical Glass and Instrument Section of the War Industries Board, and were communicated by them to the other manufacturers of optical glass.

In the first place, the filling operation required modification. Melting of the batch takes place from the top downward; the upper layer sinters together, then the more easily fusible components trickle down, leaving the upper layers impoverished in the substances usually called "fluxes." This results in the surface becoming high in silica; this is proved by skimmings from both crown and flint batches, which not only showed an actual accumulation of partially dissolved quartz grains, but also had a refractive index lower than that of the rest of the glass.

Harmful Effects of Fluxes Settling to the Bottom Overlooked

The fluxes, especially lead, tend to settle to the bottom; this is proved by the dark layer always brought up when hand stirring is begun, by tests made by plunging a long iron rod into the glass and quickly withdrawing it, and by the examination of partially melted pots which have been removed from the furnace because of leaks, and broken after cooling. In the latter case, the preponderance of silica mentioned above has also been observed.

This initial inhomogeneity, it is true, is removed by the subsequent stirring operation, and this probably accounts for its harmful effects having been overlooked. One of these harmful effects, especially in flint glasses, is due to the fact that lead-rich mixtures (for example the extra-dense flints) are extremely corrosive on the pots. By the older process this lead-rich layer is allowed to lie on the bottom of the pot throughout the filling and the fining periods, both of which periods are of some hours' duration and of extremely high temperatures. This necessarily results in greatly increased pot corrosion. In addition, the impoverishment of the upper layers in fluxes increases the time required for complete solution of the batch ingredients.

Stirring During Fill the Remedy

The obvious remedy is to stir during the fill.[1] This is not feasible until the pot is a little over half full, because the stirring rod cannot be floated before this, but as soon as feasible it should be begun, and the melt should be stirred each time new batch is added. Making such a stir during the fill should diminish pot corrosion, give glass of a better quality, freer from color, striæ and stones, and should hasten the solution of the batch and thereby shorten the melting process.

After the fill is completed, the glass must be freed from bubbles of gas arising from the decomposition of carbonates and nitrates in the batch, and from the water in the batch ingredients. In some cases these volatile components comprise one-fifth of the weight of batch filled. By the old process the bubbles are mainly removed during the fining operation, the glass being kept hot and undisturbed for some time to allow the bubbles to rise to the surface. The intermittent hand stir following supplements the fining period by removing the layer of bubbles which adheres to the pot walls, and also tends to secure uniformity in composition throughout the melt.

Stirring the Logical Way to Remove Bubbles

That seemed an illogical way to secure the desired result. In the first place, common experience is that bubbles in other liquids are more rapidly removed by stirring than by quiescence. It seemed reasonable to suppose that in a pot of glass also the bubbles will be more rapidly removed by stirring. Moreover, in the usual process the glass is not homogeneous in composition until after the fining period; the upper layer is deficient in fluxes, and hence melts less rapidly than the mass of the glass. The margin in composition be-

*Read before the American Ceramic Society at Pittsburgh, Feb. 3-6, 1919.

[1] Since presenting this paper I have heard that at one time stirring during the fill was tried at the Charleroi plant of the Pittsburgh Plate Glass Co.; others doubtless have made the same attempt.

tween an unworkably viscous glass and a workable glass is a narrow one; the stirring should prevent the upper portion being deficient in fluxes and hence too viscous to permit the free passage of bubbles. It seemed a reasonable supposition, therefore, that two of the operations to which optical glass is usually subjected could be dispensed with, namely, the long fining period and the period of intermittent hand stirring. In other words, it seemed that better results could be obtained by putting on the stirring machine immediately after the fill, and stirring continuously until the glass was free from bubbles. With this modification could well be combined a hand stir during the fill, as mentioned before.

Results Prove Reasoning Good

The best test of this reasoning is the results. The new schedule was tried out on a melt of flint glass having an index of 1.617. The melt was run at the usual temperature for this glass, 1390 deg. C. Fills were made at 2-hr. intervals, the first fill being about one-third of the total batch, and on each subsequent fill the pot was heaped up with batch. As soon as possible a hand stir was made; ten hours after the first fill the stirring machine was put on; at this time there was still undissolved batch, not all quartz. The stirring machine was run at a good speed, both with a circular and with a vertical motion. After six hours the glass seemed free from bubbles; the fire was accordingly turned off and the pot cooled and removed as usual. The entire process, from the time the pot was set until the melt was out of the furnace and another pot set, was 24 hours. When the glass was examined, it proved to be of the best quality, wholly free from bubbles, of greatly improved color, and also freer from striæ than usual.

Special Schedules for Different Types of Glass

The details of the process were subsequently modified, and special schedules were worked out for the different types of glass. Following is a sample schedule, being that for a flint having $N_d = 1.617$, $\nu = 36.5$. The pot used is 26 in. high and 28 in. in diameter, inside dimensions. The time of filling in the cullet is taken as zero hour.

SCHEDULE FOR MF$_2$ GLASS
Run at 1390 Deg. C.

Hr.	
0:00	Add cullet
1:00	Fill pot three-quarter full of batch
2:30	Fill pot with batch
4:00	Hand stir; fill pot with batch
5:30	Hand stir; fill pot with batch
7:00	Hand stir; fill pot with batch
7:30	Stirring machine on
15:00	Gas off

When cooled to the proper temperature the pot of glass is removed from the furnace, and slowly cooled in a pot arch. A new pot is set into the furnace, and given a preliminary burning, so that in 24 hours all is ready for another melt.

It may be well to emphasize one point of difference between the longer process and the 24-hr. process. In the former the melt, often with an unduly corrosive layer on the bottom, remained in contact with the hot pot for from 20 to 30 hours from the time the last fill was made until the gas was turned off; in the 24-hr. process the corresponding period of maximum corrosive action is 5 or 6 hours. As the majority of the contamination of glass, with our present raw materials, comes from the pot, the superiority of the newer process is obvious. Better color results from smaller pot contamination, as well as a greater freedom from striæ, less trouble from stones and less pot breakage.

Process Proving a Success

The first experimental pot of glass made by the 24-hr. process proved a complete success. Since that time some 350 pots of glass have been made by the shorter schedule. They comprise practically all types of glass; flints, from an extra-dense flint with refractive index of 1.76 to an extra light flint with index of 1.55; soft crowns and ordinary crowns of three different types; several types of borosilicate crown; several barium crowns, both light and dense, and several baryta flints, ranging from a light baryta flint with index 1.56 to a dense baryta flint, index 1.62. Without exception the new process has produced a better glass than the old, with a doubling of production and correspondingly lower cost.

Spencer Lens Glass Plant, Hamburg, N. Y.
Geophysical Laboratory, Washington, D. C.

Some Wild Engineering I Have Known*

By David Wesson

MANY, if not most, of the troubles in this world come from lack of knowledge of the natural laws and their proper application to practical problems. The theories of practical men are often examples of the old saying that a little knowledge is a dangerous thing. It sometimes leads to wild conclusions, as in the case of the Irish foreman who was seen thoughtfully studying a light footbridge between two buildings about 60 feet apart. Resting on the bridge was a three inch steam pipe. On being asked what the matter was, the foreman said, "That pipe carries 80 pounds of steam to the inch and 960 pounds to the foot, and the bridge is 60 feet long, which figures to 57,600 pounds, and I'm after thinking that must be an awful strong bridge."

The above incident happened before the days of chemical engineering and the chemist who worked out from his laboratory into the plant had to depend on the plant engineer to put his ideas into practice. In those days the plant engineer was more likely than not a man who had graduated from the machine shop and engine room, with a very hazy idea of physics but a strong reliance on his practical experience and ability to guess. When such a man and a chemist started to design a plant it was often a case of the blind leading the blind, and things were created which sometimes worked and sometimes did not. Difficulties arising from such causes naturally set the scientific minds of the chemists to looking into the causes, and after a proper diagnosis it was comparatively easy for the chemist to design what was needed and let the mechanic do the actual construction work. This, in the writer's opinion, was the genesis of the chemical engineer.

The writer had the privilege in 1887 of visiting most of the pioneer cotton oil refineries of the country. They were built by mechanics, not chemists, and varied greatly in design and construction. One plant was equipped with cylindrical tanks with flat bottoms and agitated with paddles revolving on a horizontal axis passing

*Extract from a paper read at the Chicago meeting of the American Institute of Chemical Engineers on Jan. 17, 1919.

through the walls of the tank. The soap stock formed in the process of refining was drawn off as much as possible from the flat bottom after each refining, and what was left went into the next batch.

Weird Refinery Practices

Another refinery showed with pride a large tank made to refine 400 barrels at one batch, but they never worked it more than half full because the heating coil was too small to heat the oil rapidly enough, though sufficiently large to condense all the steam from the entire boiler plant.

A refinery in New England noted for the fine quality of its oil did all its work with 1½-in. pipe lines and kept small pumps going 24 hours per day to handle comparatively small quantities of oil.

About 1888 or 1889 a new company put up five large oil mills which were equipped with Abendroth Root high pressure water-tube boilers and Brotherhood engines sprinkled about the large barnlike mills. Pipe covering and insulation were considered useless luxuries, and naturally the mills did not operate very successfully. The engines were natural steam hogs, and the overworked boilers were always breaking down. The management had to change the type of boilers and install central power plants with Corliss engines before their mills were put on a paying basis.

Funny Things Seen in Pipe Lines

In running pipe lines funny things happen sometimes. I remember seeing in a certain plant in Germany a pipe bent on a beautiful curve on a 3-ft. radius and connected into the sharpest kind of a right angled elbow at one end of the bend.

In a plant at Memphis some years ago a filter press was located in the top of a refinery, and the 4-in. pipe line to carry off the filtered oil to storage tanks 100 ft. distant was run by the engineer in charge with a 4-ft. drop straight to the storage tanks. When the filter pump was started up the pipe line was found too small to carry off the oil and the pan overflowed. Of course the plant was practically tied up till a chemist arrived on the scene and ordered the pipe line dropped to a horizontal position and connected with a 3-ft. vertical pipe from the filter trough. In the first case a straight line, though the shortest distance between two points, did not have more than a 6 in. of head to force the oil through it, while in the second case there was a little over 3 ft. of head and the oil ran off freely.

Engineers who should know better design large tanks to be heated by steam jackets instead of suitable coils. They do not realize that it is impossible to get sufficient heating surface in jackets, nor do they consider the danger in working with jackets at high pressure.

To Prevent Fires—Don't Erect Buildings

In a Southern city some years ago there was a plant engaged in distilling rosin to make rosin oils. Fires were frequent, and the cheap frame buildings over the stills were burned down. Finally the brilliant plan was evolved of doing the work out of doors. After that they had no more conflagrations but in cold and rainy weather the stills did not work very well. Some neighboring manufacturers engaged in distilling fatty acids tried the same scheme. The stills were out of doors, the condensers were in a fireproof house. There were no fire damages to be paid for by the insurance companies, but the quantities of fuel used in cold and wet weather, the smaller amount of fat converted into tar, the lost time and repairs soon amounted to several times more than a house over the stills, which was eventually built during the absence of the general manager, with the result that the plant became more profitable shortly afterward.

A mistake frequently observed is the design of tanks to be used under vacuum with too light materials, with the result that they collapse when put in use.

All of us looking back over our experiences can think of many other examples of wild engineering leading to more or less disastrous results. The foregoing cases are sufficient to illustrate the ease with which people who should know better are apt to transgress physical laws, which are capable of demonstration. The results, while bad enough, are infinitesimal as compared with those obtained by some of our elected statesmen, who often from ignorance and often for the sake of votes take great liberty with social and economic laws and commit social and economical engineering atrocities. The law of supply and demand, for example, is as immutable as the law of gravitation, but how often have we seen it defied by Government officials. We can hold back the flood of a watercourse for a time by constructing a suitable dam, but sooner or later if the water supplies keep increasing the dam will either overflow or be carried away and destruction will result.

Wild "Engineering" by Legislators

The prices of labor and materials of all sorts can be maintained at unnatural levels by war-time restrictions, as we have all seen, but the moment war-time conditions remove the prop from the dam, unless suitable channels are constructed to reduce gradually and safely the pent-up level of the flood, disaster is bound to ensue.

When one sees legislators passing laws preventing the formation of large industrial and transportation aggregates, it would seem that a lesson might be taken from the courtiers of King Canute, who imagined that a word from the governing powers would prevent the rising of the tide when they placed the King on his throne upon the beach.

Co-operation Needed

The lesson we must all learn from the war and the period preceding it is that the day of co-operation is at hand. By the co-operation of nations the common enemy was defeated. By the co-operation of railroads and steamship lines in our own country transportation was speeded up. By the co-operation of industries production was increased enormously. Now that the war is over the need of co-operation is greater than ever. The so-called conflicting interests of labor and capital must be caused to co-operate in such a manner that our complex social fabric shall have all parts working in harmonious unison to make the most of our natural resources and create again the enormous wealth destroyed by the war. This is the problem we all have before us and to which we will have to devote our best energies, both as worthy citizens of our great country and as members of our profession of chemical engineers.

A Proposed Metallurgical Process for the Treatment of Vanadinite for the Recovery of Lead and Vanadium*

Vanadinite Concentrate Is Fluxed and Reduced With Soda Ash, Caustic and Carbon, Giving Metallic Lead—Slag Is Elutriated, Si and Mo Precipitated With Lime—Vanadium Pentoxide 86 Per Cent Yield With Sulphuric Acid

By J. E. CONLEY

THE supply of practically all of the vanadium used at the present time in the United States comes either from the patronite of Peru, largely controlled by the American Vanadium Co. of Pittsburgh, or from the roscoelite found near Newmire, Colo., controlled by the Primos Chemical Co. Considerable vanadium is also produced from the carnotite ores of Utah and Colorado, as a by-product in the production of radium. Practically no vanadium is obtained from other vanadium ores.

Attention has been called repeatedly to the vanadinite deposits found in the United States, particularly those of Arizona and New Mexico, but thus far very little progress has been made in developing these deposits as a source of vanadium. Some time in 1910, the Vanadium Mines Co., having acquired some vanadinite deposits in Sierra County, New Mexico, erected a mill near the mine, and a reduction plant near Cutter for the commercial treatment of the ore. A little later, however, the plant was dismantled and the mines abandoned. As far as known, this is practically the only attempt ever made in this country for the industrial treatment of vanadinite.

During the last two years a 50-ton mill has been built at Kelvin, Ariz., by the U. S. Vanadium Development Co., which planned to use the Bryan process of concentration[1]. Recently, however, this property has been leased by the Allied Metals Corporation of Denver.

Plenty of evidence is available to show that vanadinite ores have been rather extensively mined and treated at Santa Marta, Spain.

In addition to these occurrences, vanadinite is known to be found in commercial quantities in Nevada, California, and several places in Mexico, as well as in Argentina.

The concentration of vanadinite is not a difficult process unless found with other very heavy minerals. The recovery of the vanadium is quite satisfactory, providing an appreciable amount does not occur as the pentoxide. Very frequently vanadium minerals show a portion of the vanadium either as the oxide, or as compounds with calcium, copper, etc., and occur in the form of a fine powder. In these cases the recovery in concentration is considerably lowered by the tendency of the powder toward sliming. The present paper, however, is not so much concerned with the concentration of vanadinite as in the treatment of vanadinite after concentration. This phase of the work was deemed sufficiently important to undertake the investigation of the metallurgy of vanadinite for the purpose of selecting and recommending a procedure.

The ore used in these experiments was in the form of concentrates obtained from Mr. E. Payne Palmer of Phoenix, Ariz., and came originally from the property near Ray Junction, Ariz., now leased by the Allied Metals Corporation. An examination of this concentrate showed it to consist largely of vanadinite and quartz, with small amounts of iron silicates, galena, calcite and wulfenite. About 90 per cent of the ore would readily pass a 30-mesh sieve. An analysis of the samples used showed:

ANALYSIS OF CONCENTRATES

	Per Cent		Per Cent
PbO	53.88	CaO	2.10
V_2O_5	12.60	Insoluble	16.93
MoO_3	1.98	Loss on ignition	2.52
Fe_2O_3	4.26	Undetermined	4.52
Al_2O_3	1.21		

From these figures it is seen that the ore is of high grade and that the recovery of the lead is an important consideration.

Preliminary Methods Tried for the Extraction of the Values

Several methods of procedure were used on these concentrates, either by trying to apply treatments already being successfully used on other vanadium minerals, or by any methods which presented possibilities. The earlier experiments were made for the purpose of extracting the vanadium, but it is seen that the treatment should be materially influenced by the lead present. Any method not adapted to the recovery of this lead must certainly be unsatisfactory.

An outline of the methods tried which were found unsatisfactory is given in Table I.

TABLE I—METHODS TRIED ON VANADINITE CONCENTRATES

Treatment	Reagents Used	Results
1. Alkaline leach...	Strong solutions of caustic and sodium carbonate	Less than 1 per cent of vanadium soluble
2. Acid leach.....	Dilute and concentrated sulphuric acid	Poor extractions
3. Acid leach.....	Dilute and concentrated hydrochloric acid	Poor extractions with permissible quantity of acid
4. Fusion.....	Niter cake; niter cake and charcoal	45 per cent extracted with niter cake; increased to 85 per cent by addition of charcoal
5. Fusion.....	Soda ash and sodium nitrate	Very fluid slags, but poor extractions

None of the methods given in Table I was found to give sufficiently satisfactory recoveries to be recommended as a process for treating the concentrates. As can be seen, none of the methods is adapted to a direct recovery of the lead.

Fusion With Soda Ash and Caustic Soda

Innumerable fusions were made with the concentrates by using soda ash, caustic soda, and mixtures of both, with the addition of charcoal. A mixture of soda

*Published by permission of the Director of the Bureau of Mines.

[1] *Eng. & Min. Jour.*, Vol. 107, No. 3, p. 149.

ash and caustic soda was eventually found that could be recommended as quite satisfactory for good recoveries at reasonable costs. The results of these fusions will be given together with the amounts of flux required.

Fusion Experiments With Caustic Soda and Soda Ash

The fusion of vanadinite with these fluxes, using charcoal as a reducing agent, favors in a measure the extraction of the lead. The lead requires a reducing fusion, while the vanadium is best extracted in an oxidizing fusion. It is the highest oxide of vanadium, the pentoxide, which possesses acidic properties and which is used in reacting with the bases to form soluble sodium vanadate. Conditions of the fusion, therefore, are favorable for the formation of the lower oxides which possess basic properties. This condition is overcome, however, by heating the slag to obtain oxidation, or by the addition of a small amount of a suitable oxidizing agent, such as niter, after the removal of the lead. Higher extractions are always secured if these precautions are taken.

Reference to Table II will show the results obtained by varying the proportions and amounts of flux used.

TABLE II.

No. of Run	Ore Used (Grams)	Na_2CO_3 (Grams)	NaOH (Grams)	Charcoal (Grams)	Per Cent V_2O_5	Extraction. Pb
1	5.0	5.0	2.0	0.2	97.8	....
2	5.0	4.0	2.0	0.2	96.0	....
3	5.0	4.0	1.0	0.2	95.6	....
4	5.0	3.0	3.0	0.2	96.2	....
5	50.0	25.0	10.0	0.5	76.0	80.0
6	50.0	20.0	5.0	2.0	74.0	80.0
7	50.0	10.0	25.0	1.25	94.6	95.8
8	50.0	10.0	20.0	1.25	95.4	91.9
9	50.0	5.0	20.0	1.25	96.1	94.7
10	50.0	0.0	20.0	1.25	94.0	95.0
11	50.0	5.0	15.0	1.25	91.3	91.1
12	50.0	0.0	15.0	1.25	9.0	92.7

In these fusions, caustic soda was found far more efficient than soda ash in rendering the vanadium water-soluble. Soda ash has been actually used, both at Cutter, N. M., and more successfully upon the vanadinite ores at Santa Marta, Spain. These ores, containing from 12 to 14 per cent vanadium pentoxide and about 50 per cent lead, very nearly correspond to the concentrates used in these experiments. It was found, however, that in any fusion in which the amount of caustic was less than 20 per cent of the weight of the ore, the vanadium extraction dropped rapidly, an objection which was but partly overcome by increasing the amount of soda ash. By reference to the table, it is seen that a sample fused with 30 per cent of its weight of caustic yielded only 9 per cent of its vanadium, but when the caustic was raised to 40 per cent, the extraction was 94 per cent.

In all the experiments made, the caustic soda, although higher priced, was far more satisfactory, both for recovery of lead and vanadium. Caustic soda was expected to give a poorer lead recovery than the soda ash, but it was actually found to give better. This can probably be explained by the fact that a more fluid slag is obtained, which facilitates the settling of the lead.

The prediction that the proportions of flux recommended will work out satisfactorily on a large scale is borne out by a run made on a 50-lb. sample. Fifty lb. of ore fused with 20 lb. of caustic, 5 lb. of soda ash and 2 lb. of coal yielded 23½ lb. of lead and gave a vanadium extraction of 89.6 per cent.

The actual literature on the treatment of vanadium ores is very meager and incomplete. Most of the information on the treatment of the ores is kept secret, and the small amount made public is carefully covered by patents. This is true of vanadium more than any other of the rare metals.

In the small amount of literature really available on the treatment of the vanadium ores, special emphasis is given to the treatment of the ores. Practically no emphasis is laid upon the recovery of the vanadium from the solutions obtained. This part of the subject is usually dismissed with some such statement as, "The vanadium may be recovered from solution by any of the well-known methods."

The recovery of the vanadium from solution as a high-grade product by an efficient and economical method is by no means the less important part of the process.

In these experiments for the recovery of the vanadium from solution, three procedures were used

1. The direct precipitation of the vanadium from the alkaline solution obtained by leaching the slag after removal of the lead. The precipitants used were:
   (a) Calcium chloride.
   (b) Chloride of lime and slaked lime.
   (c) Slaked lime.
   (d) Calcium sulphate.
   (e) Barium hydroxide and chloride.
2. Evaporation of solution to dryness in the presence of an excess of acid. The acids used were:
   (a) Sulphuric.
   (b) Nitric.
   (c) Hydrochloric.
3. The precipitation of the vanadium as the pentoxide by boiling in sulphuric acid solution.

Experiments on the Precipitation of Vanadium From Alkaline Solution

In these experiments preference was shown the common calcium salts. This was due to the cheapness of the reagents, as well as to the properties of the resulting product, namely, calcium vanadate. Many of the vanadates show a more or less tendency to form colloidal precipitates which filter very poorly. This tendency is less marked with calcium vanadate, so that a product which filters readily and permits washing is usually obtained.

The precipitation of the vanadium as iron vanadate necessitates the neutralization of the solution, as iron vanadate is best precipitated in a slightly acid solution. This was confirmed by some experiments made on the recovery of vanadium from a sulphuric acid solution obtained in treating cuprodescloizite. This precipitation, however, is being satisfactorily used at the present time and could, no doubt, be applied to this ore. This treatment is not so well adapted to the procedure adopted and to be later recommended.

Complete precipitation of the vanadium was obtained by using an excess of calcium chloride, barium chloride and calcium sulphate. With all three of these precipitants, all of the vanadium is not removed until the solution is made neutral. The principal objection to these reagents is that a large portion of the molybdenum is also precipitated simultaneously, since calcium molybdate is precipitated in a neutral solution. Complete precipitation was not obtained with a large excess of chloride of lime.

Both slaked lime and barium hydroxide precipitated the vanadium readily. Since both of these reagents increased instead of decreased the alkalinity, the result-

ing products were practically free from molybdenum. This is an important point in connection with results obtained later, since more or less wulfenite always occurs with vanadinite ores. Calcium sulphate precipitates some of the molybdenum, but only a small portion of that precipitated by either calcium or barium chlorides.

The highest grade of calcium vanadate that could be consistently maintained, and at the same time secure a satisfactory recovery, was about 16 per cent vanadium pentoxide. The grade of barium vanadate obtained from the same solution was a little better, some of the samples running as high at 21.5 per cent vanadium pentoxide. The use of barium chloride as a precipitant was not considered desirable in a commercial process.

Precipitation by Slaked Lime

The procedure followed in the precipitation of the vanadium by the slaked lime was as follows:

The alkaline solution containing the vanadium was heated almost to boiling and a thick emulsion of lime added. The mixture was then boiled and stirred frequently. This procedure was continued with the addition of more lime from time to time until the liquor showed that all of the vanadium had been precipitated. The alkalinity of the liquor is found to be increased by this treatment—a fact which assists in keeping the molybdenum in solution.

No special alkalinity was necessary or desirable for the precipitation of the vanadium, as some of the liquors after precipitation of the vanadium varied in alkalinity from an equivalent of 27.4 to 73.4 g. of sodium hydroxide per liter.

An approximate idea of the amount of lime required to precipitate the vanadium is best obtained by adding lime with the object of making a 16 per cent product, taking into consideration the fact that a portion of the silica and all of the carbonate present are also precipitated. All attempts to use less than this amount and to secure a better product by increasing the time of boiling, failed. In most of these cases, the resulting product was found to run from 15 to 17 per cent V_2O_5, and only a partial recovery was effected.

A run was made to determine the feasibility of using the 16 per cent calcium vanadate directly in the electric furnace for the preparation of ferrovanadium.

A ferrovanadium containing 38 per cent metallic vanadium was obtained. The loss of vanadium in the slag was extremely low, so that a good recovery was secured. The impurities in the ferrovanadium were all below the permissible amounts, with the exception of carbon, which can be controlled by more careful manipulation. Taken as a whole, the experiment was quite satisfactory in that both a high-grade alloy and a good recovery of vanadium were obtained.

The run would indicate that the product could be used without further treatment for the production of the ferrovanadium.

Attempts to Improve Grade of Calcium Vanadate

To be commercially satisfactory, the vanadium pentoxide content of calcium vanadate must be from 25 to 30 per cent. An attempt was made to raise the grade of the first product up to these figures by igniting the first product and using again for precipitating a new lot of alkaline solution. The ignition itself, which decomposed the hydrate and carbonate, raised the percentage from 16 to 18. The grade of the product obtained by using the first calcium vanadate instead of lime yielded a 25 per cent calcium vanadate, which was raised to 26 per cent on ignition. Thus it is seen that a product just on the lower limit of the commercial product was secured. A third precipitation, by using the second product, only raised the grade by an additional 1 per cent. This scheme can be applied for obtaining a commercially satisfactory product at what would seem a very reasonable cost. Two precipitations seem to be all that could be advantageously used.

Neutralizing Alkaline Solution With Excess of Acid and Evaporating to Dryness

An attempt was made to obtain the vanadium as the oxide by adding only sufficient acid to insure a slight excess and then evaporating to dryness. The soluble salts were leached out with water, leaving behind the crude V_2O_5. The common mineral acids, nitric, hydrochloric and sulphuric, were used.

The chief difficulty in this scheme was to obtain a good recovery with the small amounts of acid commercially possible. Another objection is the interference of the silica, which is simultaneously rendered insoluble. A larger portion of the molybdenum is also obtained, which is objectionable if the vanadium is to be used for steel.

The most promising results obtained by this method were secured by neutralizing with sulphuric and adding nitric acid for the excess. By this procedure a 92 per cent recovery of the vanadium in solution was obtained. The resulting product showed 66.8 per cent V_2O_5. The amount of nitric acid used, however, was too great to be satisfactory. The expense involved in evaporating the solution to dryness, the amount of acid required, and the contamination of the resulting product with molybdic oxide and silica are the principal objections to this procedure.

Precipitation of Vanadium Pentoxide by Boiling in Acid Solution

This method of recovering the vanadium from solution was considered the most feasible, so that considerable time and care were used in working out the conditions best suited for a good recovery of a high-grade product.

In the early experiments, it was hoped that by simply taking the alkaline solution and adding sufficient acid to make the desired concentration, the vanadium would be readily precipitated by boiling. In the attempt to carry this out, serious difficulties were encountered. Some trouble was encountered from the tendency of the silica to separate out during the neutralization. The difficulty, however, was easily overcome by diluting the alkaline solution to such an extent that after neutralization with acid the concentration would be about 10 g. per liter. It was considered that this concentration could be easily maintained on a large scale. The possibility of treating the alkaline solution to remove the silica was also considered, but the silica was found to carry down a considerable amount of vanadium. This removal had to be done upon the alkaline side and, therefore, under conditions favorable for the precipitation of many vanadates. The trouble from the silica was finally eliminated by diluting the alkaline solution and then adding to the acid, so that the resulting mixture was always on the acid side. These conditions are more favorable

for holding the silica and vanadium in solution, since it is unnecessary to pass through the neutral point to get the desired acidity.

Preference Given to Sulphuric Acid

Preference was given sulphuric acid, although a few experiments were made with nitric and hydrochloric acids. A series of runs were made with a gradually increasing acid concentration to determine the acidity best suited for the maximum recovery. The results obtained may be seen by reference to Curve I of Fig. 1.

The precipitation of the vanadium depends upon the formation of pyrovanadic acid ($H_4V_2O_7$), which is a brownish precipitate very similar to ferric hydroxide. This compound forms only in extremely dilute acid solutions when sulphuric acid is used. The experiments were then made to determine the acidity most favorable for the formation of the pyrovanadic acid, which separates out readily on boiling. Low acidities favor the formation of metal vanadates, and high acidity favors the formation of vanadium sulphates,

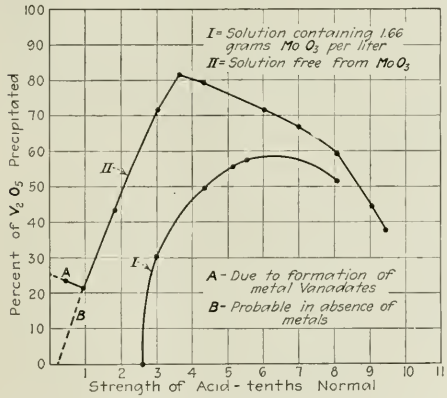


FIG. 1. CURVES SHOWING AMOUNT OF V_2O_5 PRECIPITATED BY BOILING IN SULPHURIC ACID SOLUTION 10 G. OF V_2O_5 PER LITER

which are soluble and are not thrown out of solution by boiling.

Curve I of Fig. 1 shows the results secured by using the alkaline solution obtained by leaching the slag from the fusion. This solution contains, after acidifying, silica, molybdenum and sodium sulphate as the principal impurities. No precipitation of pyrovanadic acid was obtained until the acidity became about 0.25 N, at which point precipitation began. The amount precipitated increased up to a concentration of 0.5 to 0.6 N and then decreased. The maximum recovery could not be raised above about 58 per cent. Even the addition of oxidizing agents failed to materially increase the recovery.

A synthetic solution of vanadium prepared by dissolving some pentoxide in a sodium carbonate solution showed very different results. Precipitations began at a much lower acidity and increased rapidly until a concentration of from 0.2 to 0.3 N gave a 90 per cent precipitation.

Results showed that some impurity present in the alkaline solution was responsible for the trouble. The principal impurities, silica and sodium sulphate, were successively eliminated as possibilities until some molybdic oxide was added to a synthetic sodium carbonate-pentoxide solution and an attempt made to precipitate the vanadium as before. Results obtained were:

No. of Test	Grams V_2O_5 per Liter	Acidity of Sol.	Ratio $MoO_3 : V_2O_5$	Per Cent Precipitation
1	10	3/10 N	0	87.3
2	10	3/10 N	1:6	35.1
3	10	5/10 N	0	86.9
4	10	5/10 N	1:6	65.3

The silica and sodium sulphates were found to retard slightly the precipitation of the vanadium, but the real interfering agent was the molybdenum present in a ratio to the vanadium of approximately 1 to 6, as shown in the table. The interference can be explained only by the possibility of the formation of certain soluble molybdenum-vanadium complexes. A scheme for eliminating the molybdenum was then necessary. The use of hydrogen sulphide was considered, but the precipitation of molybdenum as the sulphide is tedious and incomplete unless done under pressure. As a matter of fact, it is really a difficult analytical procedure. Another more serious objection to the use of hydrogen sulphide is that it quite readily reduces the vanadium to the tetroxide, which does not favor subsequent precipitation as the pentoxide.

The Method Recommended

The method recommended for eliminating the molybdenum is as follows:

As will be remembered, under the precipitation of the vanadium from the alkaline solution by the use of lime, it was found that the resulting calcium vanadate con-

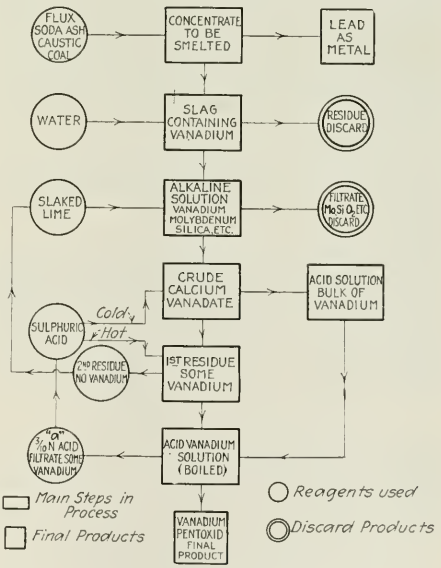


FIG. 2. DIAGRAM OF PROCESS

tained only a trace of molybdenum. This scheme was then used to dodge the molybdenum. The calcium vanadate was made by treating the alkaline solution with lime and then dissolving in sulphuric acid and throwing the vanadium out by boiling.

Curve II of Fig. 1 shows the results attained from a solution obtained in this manner. The recovery is a little lower than that from the synthetic sodium carbonate solution, but much higher than that from the alkaline solution.

The actual outline of the process finally recommended for the treatment of vanadinite concentrates is given in Fig. 2. Each ton of concentrates is smelted with 800 lb. of caustic soda, 200 lb. of soda ash, together with sufficient coal or coke to reduce the lead. The slag is then taken through the steps indicated to produce the high-grade vanadium pentoxide as a final product.

RESULTS OBTAINED ON 50 POUNDS OF ORE

Weigbt of ore	50.0 lb.
Weight of caustic soda	20.0 lb.
Weight of soda asb	5.0 lb.
Weight of coal	3.0 lb.
Weight of lead recovered	23.5 lb.
Percentage lead recovered	93.2
Weigbt of slag recovered	42.0 lb.
Percentage of vanadium extracted	89.6
Percentage of vanadium recovered as calcium vanadate	89.6
Percentage of V_2O_5 in calcium vanadate after drying	13.64
Percentage of V_2O_5 in calcium vanadate after ignition	15.90
Percentage of V_2O_5 in final product	86.6

The actual amount of sulphuric acid consumed in dissolving the calcium vanadate was not determined on this run, since it is necessary to make a number of successive runs to determine the acid consumption. Tests were made, however, on smaller lots, and it was found that about 60 per cent as much acid as calcium vanadate would be required. Assuming a 16 per cent calcium vanadate, it would require about 4 lb. of 60 deg. B. sulphuric for each pound of vanadium pentoxide, i.e., for chemical alone it would cost only about four or five cents per pound of vanadium pentoxide.

The grade of the final vanadium pentoxide prepared by this treatment varies from 85 to 90 per cent V_2O_5. The recovery is quite satisfactory, since it is maintained at the same level as the actual recovery of the vanadium from the slag. The only solution discarded, excepting as the volume of the solution after precipitation of V_2O_5 becomes too great, is the filtrate from the precipitation of the calcium vanadate. The actual acid consumption is large at the beginning of the cycle, since the excess of lime must be converted to sulphate along with the calcium vanadate; but when the calcium sulphate is used, very little acid is required to dissolve the calcium vanadate.

Care must be taken when the $CaSO_4$ is used to precipitate the vanadium, since the tendency of molybdenum to precipitate with $CaSO_4$ is much more pronounced than with CaO. Precipitation is only complete with $CaSO_4$ when the alkaline solution becomes neutral —a fact which accounts for the tendency of molybdenum to separate out also. A little care, however, avoids the precipitation of much of the molybdenum.

ESTIMATE ON COSTS OF TREATMENT
Per Ton of Ore

800 lb. caustic soda at $4.30 per cwt	$34.40
200 lb. soda ash at $2.90 per cwt	5.80
900 lb. 60° B. sulphuric acid at $16.00 per ton	7.20
200 lb. lime at $25.00 per ton	2.50
100 lb. coal at $2.75 per ton	.15
Cost for chemical treatment, labor	15.00
Total cost of treatment	$65.05

VALUE OF PRODUCTS AT PRESENT MARKET PRICES

930 lb. lead at $5.00 per cwt	$46.50
225 lb. vanadium pentoxide, 85-90 per cent, at $1.20 per pound	266.00
Total value of products	$312.50

To the above cost of treatment must be added the costs of mining, milling and concentrating, which are extremely variable factors, depending upon the location and facilities for mining. It would seem though that the difference between the value of the products and the costs of treatment would allow an attractive margin for the production of the concentrates.

The author wishes to gratefully acknowledge the many helpful suggestions received from Dr. S. C. Lind of the Rocky Mountain Station of the Bureau of Mines, under whose direction this work was carried on.

Golden, Colo.

Japanese Industrial Notes

THE Oriental Steel Manufacturing Co., Ltd., is making rapid progress. The smelting furnace ordered from the United States has arrived at the Tobata (Kyushu) works. When it has been installed, it is expected to have a capacity of 150 tons of iron per day.

Overproduction of Pig Iron

Japanese iron producers are now suffering from the inactivity of the iron markets due to the sudden ending of the war. The question of making an adjustment in prices has recently been officially decided. At first they intended to sell 50,000 tons of pig iron to the government. But this proposal was not accepted and the government purchase was settled limited to 13,900 tons. The sellers of iron being dissatisfied with the above amount, a further purchase of 2400 tons was made. There remains 33,700 tons unsold, and the producers are now looking forward for a third government purchase. It is said that this will by no means bring relief to the present troubled conditions of the Nippon ironmongers, unless the output is limited by the side of iron producers.

Fluctuations in the Wages of Artisans

The wages of artisans which have advanced more than 100 per cent are: Soy brewers, brick layers, Japanese cloth tailors, paper hangers, male servants, Japanese clog makers, saddlers, shipbuilders, gold and silver smiths, joiners. From 50 to 100 per cent: Coolies, gardeners, painters, sawyers, machinists, paper makers, founders, roofers. Up to 50 per cent: Plasterers, smiths, carriage builders, fishermen, confectioners, type compositors, foreign style tailors, stone masons, dyers.

Phosphate Rock

Manufacturers of phosphate fertilizers recently held a meeting at the Nihonbashi Club, Tokyo. The allocations of the following concerns were decided: Dai Nippon Artificial Fertilizer Co., Kanto Sanso Co., Nippon Fertilizer Co., Sumitomo Fertilizer Manufacturing Co., Taki Fertilizer Works, Osaka Chemical Works, Sakai Sulphuric Acid Manufacturing Co., Niigata Sulphuric Acid Manufacturing Co., Kokuriku Artificial Fertilizer Co.

Japanese Society of Chemical Industry

Japanese Society of Chemical Industry (in Japanese, Kagaku Kogyo Kyokwai) has recently been organized by eminent chemists under the auspices of Viscount Kiyoura to give an impluse to the chemical industry.

Japanese-American Syndicate for Manufacturing Aluminium

The problem of establishing a new co-operative concern under Japanese-American capital is now making great headway. The capital is said to be 10,000,000 yen and the object of the concern is to establish an aluminium manufacturing plant in Fushiki harbor, Toyama Prefecture, with the hydraulic power of the river Jintsu. The privilege of using the water for generating hydro-electric power is being arranged with Mr. Inoue, Governor of Toyama Prefecture.

Fundamental Principles to Be Considered in the Heat Treatment of Steel

Notes Recording Some of the Fundamental Principles Which a Metallurgist Should Use as a Check-List When Engaged in an Investigation of Heat Treatment, Selection of Metal, Furnaces, Heating and Quenching Practice, Pyrometry, and Physical Tests

By R. A. HAYWARD
District Inspection Metallurgist, Rochester District Ordnance Office

HEAT treatment of steel is entirely for quality, and in no case should quantity of production or cost of materials be allowed to influence a metallurgist in heat treating a given steel in an improper manner. If anything at all is done, it should be heat treated so as to give the best properties obtainable from that steel and not simply properties which will pass the minimum specifications.

There are three general types of heat treatment:

First, one type is known as softening. Within this branch come the two processes known as normalizing and annealing. Normalizing means heating the steel to a temperature exceeding its upper critical range and allowing it to cool freely in the air. The maximum temperature shall be maintained for about fifteen minutes and should exceed the upper limit of the critical range by at least 50 deg. Annealing means heating the steel above the upper critical range and allowing it to cool very slowly, such as cooling it in the furnace in lime, mica or similar non-conductive material. The object of these two processes is to remove all stresses which have been placed in the steel by previous working, and to refine the crystalline structure. In general, steel will respond more readily to hardening if it is previously subjected to a softening treatment.

The second general type of treatment is known as hardening. This means heating the steel above the upper critical range by about 50 deg. to 100 deg. and quenching in a suitable fluid, such as water, brine or oil.

The third type of treatment is tempering or drawing. Tempering means heating the steel below the critical range with the object of reducing the hardness, or increasing the toughness to a greater or less extent. This operation may be followed either by slow cooling or by water quenching without materially affecting the final results.

It is well to investigate the actual effect of water quenching after drawing for each type of steel. It is definitely known that chromium-nickel and chromium-vanadium steels, when quenched in water after drawing, show a much higher resistance to shock than when cooled slowly. In the case of straight carbon and straight nickel steels, on the other hand, the resistance to shock does not seem to be affected by the method of cooling after tempering.

Other terms often used in heat treating work are: Cementation, or case hardening; heating a steel above its normalizing temperature in a medium which will increase its carbon content; core of a case hardened bar is the interior portion of the bar which is unaffected in composition by the carbonizing process; bluing—reheating a steel to a specified temperature and allowing it to cool in air.

In the selection of steels to be used in different parts of machines, careful attention should be paid to the manner in which the part in question operates. First, the amount of stress which the piece is expected to stand should be calculated, then the factor of safety should be applied. Then the weight and size of the piece should be determined, also it should be noted whether it will be subjected to wearing, and whether it must withstand shocks or alternating stresses. After these points have been determined, the steel may be selected according to the following general specifications:

Stresses	Metal to Be Used	Composition
Parts subjected to but slight or practically to no stresses or wear.	Medium carbon steel (when aluminium alloys are not permissible).	C, 0.30 to 0.40% Mn, not over 0.75% P, not over 0.05% S, not over 0.05%
Severe wear, but not severe fatigue stresses.	Low carbon steel suitable for case hardening.	C, not over 0.20% Mn, not over 0.50% P, not over 0.05% S, not over 0.05%
Severe wear and severe fatigue stresses.	Low carbon nickel-chromium steel suitable for case hardening.	C, not over 0.20% Mn, not over 0.50% P, not over 0.05% S, not over 0.05% Ni, not less than..... 2.00% Cr, not less than . 0.50%
Severe fatigue stresses, but not severe wear.	Medium hard nickel-chromium steel.	C, 0.30 to 0.40% Mn, not over 0.75% P, not over 0.05% S, not over 0.05% Ni, 2.50 to 3.50% Cr, 0.50 to 1.00%
Severe fatigue stresses or wear or both, when smaller ductility is permissible.	Self-hardening nickel-chromium steel.	C, 0.30 to 0.50% Mn, not over 0.75% P, not over 0.05% S, not over 0.05% Ni, 3.00 to 4.50% Cr, 0.50 to 2.00%
Distortion and softening at high temperature valves.	Tungsten high speed steel.	C, 0.40 to 0.70% Mn, 0.20 to 0.40% W, 12 to 18% Cr, 2 to 4% Va, 0 to 1%

In order to heat treat material, it is absolutely essential to have accurate chemical analysis of the material to start with. It is possible to equip a chemical laboratory for the analysis of all types of alloy steels for about $1500. This includes electrical combustion furnaces for the determination of carbon, but it does not contain any equipment for determining elements by electrolysis.

If the chemical analysis is carefully made, the carbon determination should be accurate to within two points of either side of the true amount. The accuracy in determining all other elements should be in the same ratio. Quite often failures in heat treatment are blamed on inaccurate chemical analyses. About 75 per cent of these complaints can be explained by investigating the actual treatment given the material; in some few instances, the chemical analysis will be found in error.

The success of any heat treatment depends, to a great extent, upon the type of furnace used. Every furnace should be such that the material being heated will receive a uniform heat at all parts and should be capable of accurate temperature control. Fuel economy should always be a secondary consideration.

Care should be taken to see that the furnace, whatever the type may be, is large enough to hold the work, and large enough so that the temperature is not materially reduced when the cold metal is placed in it. It should be so built that the work will receive an enveloping heat, and not a concentrated heat from the flame. In case the furnace is overfired, the temperature gradient of the furnace should be watched carefully and care taken that the floor is kept up to heat.

Furnaces are generally heated either by oil, gas or electricity. Oil firing is satisfactory for large furnaces where an accurate temperature control is not required and where an oxidizing atmosphere is not detrimental. Gas-fired furnaces are capable of more delicate control, both regarding temperature and the oxidizing nature of the burning gases. In case either of the above fuels are used, care should be taken to see that there is proper space in the furnace appropriated for a combustion chamber, and that the hot gases do not strike one part of the material more than another. Electric furnaces are capable of very accurate control. In cases where delicate heat treatment is being done, and where the rejection of a furnace-load of material would be costly, it pays to install this type of apparatus.

Judging a Furnace

In judging any furnace, the following things should be borne in mind:

1. Uniformity of heat.
2. Rate of heating.
3. Method of loading and unloading.
4. Quenching arrangements.
5. Initial cost.
6. Upkeep and repair.
7. Thermal efficiency.

In cases where large quantities of material are to be heat treated, it is well to consider a continuous furnace for the work, but care should be taken that it is long enough to insure uniform heating. If large material is to be rolled through the furnace, the underfired furnace will be found well adapted to the work. In case the material is conveyed through the furnace on trays, the overfired muffle furnace will be found satisfactory. Conditions cannot be controlled very accurately in continuous furnaces.

For heat treating small miscellaneous parts, the ordinary underfired tool-room furnace of sufficient size has been found very satisfactory. In all cases, the material should be piled loosely, allowing a good circulation of gases, and the furnace should not be overloaded.

Speed of Heating

In general, it is permissible to bring the steel up to temperature quite rapidly. In the case of large forgings, however, it is necessary to heat them more slowly. If the outside of such forgings heats too rapidly, it will expand and cause severe tensile stresses in the material. It is thought by some metallurgists that rapid heating has developed "flakes" in nickel steel gun forgings.

The time required to bring any piece of steel up to the desired temperature and the actual temperature desired are questions which have to be settled for each individual case. In general, when hardening, the metal should be quenched as soon as it has reached the desired temperature and has soaked long enough so that the temperature is uniform throughout. In the case of drawing, the material should be held at the desired maximum temperature as long as practical. In cases where very accurate work is desired on small parts, lead baths or salt baths are used for heating the material. Where trouble is experienced with the lead sticking to the material, this can be avoided by first dipping the steel in a solution of potassium cyanide.

Quenching Practice

Quenching tanks should be placed close to the hardening furnaces and arrangements should be made to transfer the hot metal into the liquid as rapidly as possible. Tanks should be covered with a steel lid when not in use.

Every tank should be provided with equipment to circulate and cool the quenching medium. It is better to have a small quenching tank with a high rate of circulation than a larger tank with a slower rate. The oil may be cooled by passing it through a refrigerating machine, by piping it through cold running water, or by cooling with air. In cases where a great many small parts are quenched in a tank at once, provision should be made to have the oil circulate freely among the different parts, or uniform results will naturally not be obtained.

Quenching Media

The most common quenching media are oil, water and brine. Hot lead has been used in some instances, also soap solutions and mixtures of oil and water. Brine gives the harshest quench of all, water next, then the various grades of oil. There is, however, quite a wide gap between the results obtained from water and oil.

Quenching should be considered as a rapid removal of heat from the material down to a temperature of about 500 deg. The rate of cooling steel through the critical range determines the hardness of the material in practice. This rate of cooling has a marked effect on the final physical properties of the steel after it is drawn. Thus, in general, the harsher the quench, the higher the elastic limit will be, in comparison with the tensile strength, but the ductility does not seem to be materially affected.

If water or brine is used as a quenching medium, its temperature should be above 100 deg. F. In case of large forgings, this temperature may be from 100 to 110 deg., while for smaller forgings, it should be increased to 150 or 200 deg.

In using water or brine, there is great danger of developing quenching cracks or of warping the material. For this reason the steel should be immersed in the quenching medium in line with its longitudinal axis, and should be removed when it has reached a temperature of about 500 deg. F. since most of the cracks and warping occur as the steel is quickly cooled below this temperature. There is also danger of developing steam pockets; the steam acts as a heat insulator and causes soft spots in the steel. Only forgings which are symmetrical and of considerable size should be quenched in water.

In general, it is better and safer to quench in oil, providing this medium will give a harsh quench enough

to produce the desired properties. A good quenching oil should not deteriorate upon use, and is judged according to the following physical properties:

1. Specific heat.
2. Heat conductivity.
3. Specific gravity.
4. Viscosity.
5. Flash point.

The temperature of the quenching oil should be over 100 deg. The actual temperature of the medium seems to have little effect on the physical properties of the hardened steel; still it is much more economical to maintain the oil at about 150 deg. and it pays to install sufficient cooling area to keep the oil at this temperature. One gal. of high-grade quenching oil, when used under economical conditions, should quench about 1500 lb. of steel—this figure is contingent on the size and nature of the pieces. Steel taken from oil should be placed on tables, so that the oil will drain back into the tank.

Pyrometric Control

In order to heat treat material intelligently and to obtain uniform results, it is necessary to have all the furnaces adequately equipped with pyrometers.

Base metal thermocouples are commonly made of iron and constantin wire, or chromel and alumel wire. The iron-constantin couple seems to be somewhat more accurate, but it does not seem to have as long a life as the chromel-alumel couple. The platinum-platinum rhodium couple is the most accurate, but the cost of the rare metals makes them prohibitive for commercial use, except for controls.

Electrical meters usually record the potential difference between the hot end of the thermocouple and its cold junction. It is absolutely essential to have the cold junctions of any pyrometric system located in such a place that its temperature will remain practically constant. This can be accomplished most readily by burying them in the ground at a distance of 4 or 5 ft. from the furnace. However, other arrangements which provide a constant temperature are satisfactory.

There are two general types of meters. One is a low-resistance instrument (milliammeter or galvanometer) and the other a high-resistance instrument (millivoltmeter). The low-resistance instrument is more robust than the other, but it is effected to a greater extent by variations in the resistance of the leads, poor connections, etc.

For more accurate work a potentiometer with an iron-constantin couple seems to give good results. This instrument can also be used with couples made of any other combination of metals, since in this system, an electromotive force is introduced into the circuit which just counteracts the electromotive force generated in the thermocouple. When the indicator on the potentiometer shows that no current is flowing, the amount of electromotive force introduced is read and transferred into degrees by the use of a calibration chart. This type of installation is not affected by the resistance of the leads or by oxidation of the thermocouple. It registers accurately as long as part of the weld in the thermocouple holds together.

Any pyrometric system is only as accurate as the calibrating and checking equipment available. Thermocouples should be checked at least once a week, preferably by placing a standard base metal couple beside thermocouples that are being used in furnaces and reading temperatures registered by the two. The standard base metal couple should also be periodically checked in an electric furnace against a standard rare metal couple, or it may also be checked by melting points. In this case, care should be taken that the melts are pure and that it is used in a graphite or ceramic container. Iron tubes should not be used in the salt bath. A vertical electric furnace about 3 ft. long and 3 in. in diameter will be found well adapted to such work.

Placing the thermocouple in the furnace is very important. Care should be taken that the temperature at the end of the thermocouple is the same as that of the material being heat treated. (This can be checked in hardening furnaces by use of an optical pyrometer—the Leeds Northrup pyrometer is very satisfactory for this work.) If the pyrometer reads 1550 deg., it is no proof that the material is at this temperature, but if thermocouples are properly installed and checked, one should be able to control the temperature of the material to within 10 deg. on either side of that desired. In general, however, the temperature is rarely controlled within a range of 20 deg. plus or minus.

Physical Tests

After the material has been heat treated, it should be subjected to some sort of a physical test, the tensile test being universally used. When the test bar is pulled, the elastic limit, tensile strength, per cent elongation and per cent reduction of area should be calculated and recorded, together with the nature of the fracture.

The elastic limit may be determined in several different ways, the most accurate method being the "increment" method. This consists in clamping an extensometer on the test bar and noting the stretch as each 1000 lb. per sq.in. load is added to the bar. The point at which the stretch ceases to be proportional to the added load is taken as the elastic limit to the specimen.

Other methods for getting the elastic limit are the "run extensometer" method, "scribe" method, "modified scribe" method and "drop of the beam." In the "modified scribe" method, the test specimen is first scribed with dividers set at a length equal to the gage length of the test specimen, one end of the divider being set in a punch mark on the specimen. A load corresponding to the minimum elastic limit required for the material is then applied, care being taken that the beam balances under this load. The load is then released and the test specimen is scribed again. If after this second scribing two distinct lines are seen, the elastic limit is considered as having been exceeded, while in case there is no permanent set in the specimen, the elastic limit has not yet been reached.

Per cent elongation and per cent reduction of area are an indication of ductility. Per cent elongation is contingent upon the relation between the original area of the specimen and the gage length, and the following general relation should exist:

$y^2 = 20x$, where y is the gage length and x is the area of the test piece.

Number of Tensile Tests

The number of tensile tests that should be taken from any lot depends entirely on the importance of the properties measured by this test as related to the stresses set up in the piece when in operation.

Compression tests are often made on steel and cast iron in order to obtain information as to the amount of direct loading the material will stand and also as a

measure of the ductility of the material. A compression test specimen is usually a cylinder, whose diameter is equal to its height. The specimen is then compressed to one-half of its original height if it does not break before that point. The elastic limit in compression can be determined the same as in tension.

Bending tests are often made to determine the ductility of steel. This test generally consists of bending the piece flat about a rod whose diameter is equal to the thickness of the piece.

Torsion tests are also made in a twisting machine which measures the amount of force required to twist the steel to a certain angle. This test is applied to steel which is to be used for axles, crank shafts or similar work.

Fatigue tests are often made on steel to determine the amount of alternating stresses the material will stand before breaking. This test generally consists of rapidly bending a piece of steel back and forth without exceeding the elastic limit, and measuring the number of such bends required to break the material.

Shearing Tests

Shearing tests are often made on steel which is required to stand up under shearing stresses. In this test, a specimen is broken in a machine which measures the force required to shear a standard specimen in two. This force is then divided by cross-section area.

Impact tests should be made on all material which will be subjected to shocks. The most common types of impact machines are the Izod and the Charpy. Both have a heavy pendulum, which swings from a certain height and breaks the specimen, the amount of energy remaining in the pendulum being measured by the distance which it swings after striking the specimen. It is very important to have the specimens accurately machined for this test, and if it is notched, it should be done on a special milling machine which is used only for this one purpose.

Drop Tests

A drop test is often used on cast iron and steel. This consists of dropping a weight from a specified height repeatedly until the material breaks, or by starting at a specified height and increasing the drop by a certain increment each time until failure. The test bar is supported on knife edges, the radii of which have a very important influence on the results.

It is impossible to estimate the impact resistance of a piece of steel by any other test; that is, steel which has the same chemical analysis when heat treated in different ways may give exactly the same tensile properties, but have entirely different resistance to shock. This is particularly true of steels containing chromium and vanadium.

The hardness of steel is measured in several different ways. The Brinell test consists in applying a weight of 3000 kg. through a 10 mm. steel ball upon the material for 30 sec. The diameter of the impression is then read by a microscope, and the hardness number taken out of a table. This test is fairly indicative of the tensile strength of the material. From the Brinell number, knowing the chemical analysis of the steel, one should be able to estimate the tensile strength to within 5000 lb. per sq.in. It is also an excellent test to check the uniformity of heat treatment. In testing a lot of material, it is well to Brinell a portion of them and then select the softest one for tensile tests. In this way it is certain that the softest piece in the lot meets the physical requirements.

Hardness may also be tested by the Shore scleroscope. In this test a tiny pointed hammer is dropped on the material from a certain height and the height of rebound is measured. The surface tested should be carefully smoothed and the small hammer should not drop twice in the same place. The piece being tested should also be supported solidly. The results of this test cannot be interpreted to read elastic limit, tensile strength or Brinell hardness with any degree of accuracy; however, there is a very general relationship between these properties.

Special tests are often made on small heat treated parts on specially designed machines, which aim to set up stresses in the piece similar to the ones it will be required to resist in operation. These tests are either run until the piece breaks, or until it has withstood the tests for a specified time. Such tests are very satisfactory and should be applied wherever possible.

Micrography

Microscopic examination of steel is of great assistance to a metallurgist, and at times indispensable. For tracing causes of failures and for laying out heat treatment for new parts, such examination can be used to great advantage.

A cubical specimen about $\frac{3}{4}$ in. on a side is about the best size to handle in polishing. One surface should be ground or filed flat. It should then be polished on a regular polishing wheel until all scratches are taken out. It is well to examine a surface under a microscope before etching. The specimen can then be etched in a 5 per cent solution of nitric acid and alcohol, or a 10 per cent solution picric acid in alcohol.

Any examination of steel is really incomplete without the microscope. It is an excellent check on all other tests and analyses. Before making any definite statements concerning the structure of the steel, the chemical analysis should be known, together with the heat treatment the material has received.

Conclusion

As stated in the first part of this paper, heat treatment work is entirely quality work. In order to accomplish this, it is necessary that every man working in the heat treatment department be intensely interested in his work. In order to maintain the interest of the men, it is necessary that every man should be educated as much as possible in the line of work he is handling and should view his work at all times with an inquiring attitude. Each man should be encouraged to think about the work he is handling and should be allowed to exercise the creative side of his nature whenever possible. Responsibility should also be placed upon the men who are actually performing the operation; this can be accomplish by allowing the men to visualize their work by the use of graphs and charts. Interest can be maintained by keeping progress reports of the men throughout definite periods. These records should be open to the men at all times; they should be kept only with the idea of showing the men to what extent they have mastered the work they are handling, and to see the comparison between what they and the other men are doing. When the heat treatment department is organized on these principles, the maximum production will be obtained with the best quality.

Cost information, similar to the following, should be available to the metallurgist:

1. Direct labor cost.
2. Indirect labor.
3. Overhead.
4. Price of materials used.
5. Quantity of material heat treated.
6. Quality of material heat treated.
7. Quantity of material quenched per gallon of quenching oil used.
8. Cost per unit weight of material heat treated.

These figures should be carried forward on chart record.

Rochester, N. Y.

Determination of Uranium, Zirconium, Chromium, Vanadium and Aluminium in Steel—I

By Charles Morris Johnson

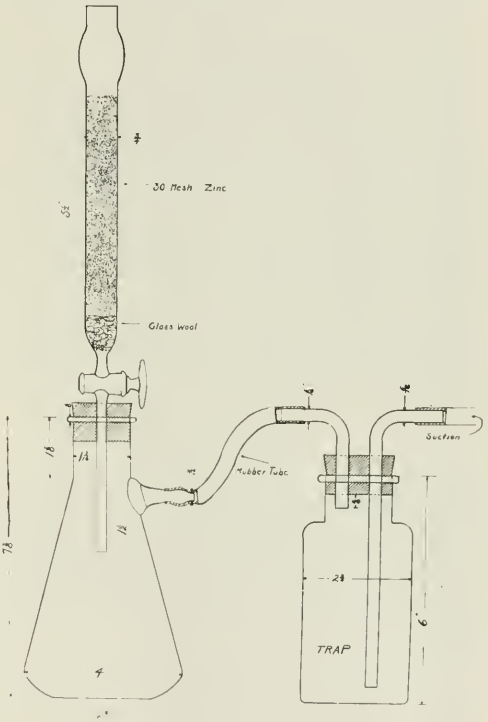
THE feature of the following method is to remove the bulk of the iron from the uranium, zirconium and aluminium before making determinations of these elements by fractional precipitation by ammonia. The analysis can then be proceeded with in a simple and accurate way. The separation of the bulk of the iron is based on the fact that when ammonia is added to iron in the ferrous state the unoxidized iron is first converted to double sulphate of ferrous iron and ammonium and remains in solution. By adding the ammonia very slowly with constant stirring a point in the neutralization is reached where a slight reddish precipitate forms. On the addition of a few drops more of ammonia this reddish precipitate darkens. At this stage all the aluminium, zirconium, uranium, etc., are precipitated, while 99 per cent of the total iron remains in solution as double sulphate and is removed by filtration. By actual test with 10 g. of plain steel to which uranium salt was added, over 99 per cent of the iron was removed.

Uranium in Plain Steel

Dissolve on a low flame 5 g. of drillings in 50 cc. 1:3 sulphuric acid diluted with 50 cc. of water, using a 600 cc. beaker. For steel containing less than 0.1 per cent uranium use 10 g. of sample. When action is over, filter off the insoluble residue, which is mainly carbide, and wash it 25 times with dilute sulphuric wash (25 cc. of 1:3 H_2SO_4 diluted with water to 600 cc.). Call this filtrate and washings *A*. The insoluble residue may contain U, so it must be ashed in a platinum crucible at a low heat; cooled; 6 cc. of HF plus 6 cc. of 1:3 sulphuric acid added; evaporated to thick fumes of SO_3; cooled; a little water added; heated to dissolve the sulphates and the clear solution is added to *A*. Then dilute to 250 cc. volume with water and add 1:1 ammonia with constant stirring until a slight precipitate forms. Then continue to add ammonia drop by drop until the precipitate just begins to take on a blackish tint. At this stage all the uranium has been precipitated with only a small portion of the iron.

To assure a complete precipitation of the uranium, add about 10 more drops, but do not exceed 10 drops, as excess ammonia only brings down a greater bulk of the iron. Filter off the precipitate at once on a double 15 cc. filter paper and redissolve it in 50 cc. 1:1 HCl. First warm up the acid in the beaker to dissolve any iron that sticks to the sides; then pour the hot acid on the precipitate, catching the filtrate in a 600 cc. beaker. Pour hot filtrate on the filter two or three times until all the iron is in solution. Wash the filter paper about 25 times with dilute HCl wash (1:40). Now peroxidize the filtrate and washings by adding, slowly, with a porcelain spoon, about 1 g. of sodium peroxide at a time. After each addition wash off the sides of the beaker with water and stir the solution well. Keep on peroxidizing until all the iron is precipitated and the solution is alkaline when tested with red litmus paper.

Now add about 5 g. of sodium carbonate and 5 g. of ammonium carbonate to keep the uranium in solution.



REDUCTOR FOR U AND FE

Stir well and bring it just to a boil. Filter off the iron and wash it about 25 times with sodium and ammonium carbonate wash (2 g. of Na_2CO_3 and 2 g. of $(NH_4)_2CO_3$ dissolved in 600 cc. of water). To the filtrate which contains all the uranium add 1:1 HCl with stirring, till solution no longer turns turmeric paper even a faint brown, but still reacts alkaline when tested with red litmus paper. Keep the beaker covered when adding the acid, as the effervescence is very strong, especially toward the end of the neutralization. Boil off the CO_2 and then add slowly with stirring (keeping the beaker covered) 1:1 HCl till the solution is slightly acid. No more effervescence at this stage, but the acid falls down to the bottom of the beaker without action.

Boil the acid solution for half an hour to remove CO_2 and after it has been cooled add 5 g. of ammonium phosphate $(NH_4)_2HPO_4$; stir till dissolved; then add 1:1 ammonia till it smells ammoniacal and add 1:1

acetic acid till the solution is acid; now add 5 cc. acetic acid in excess. The acetic acid keeps any chromium and vanadium present in solution. Chromium does not interfere with the uranium titration, but vanadium interferes greatly.

After a few hours, filter off the uranium and wash it about 40 times with acetic wash (5 cc. of ammonium phosphate, 10 cc. 1:3 H_2SO_4 diluted with 100 cc. of water, stir till dissolved, make it slightly ammoniacal and then acid with acetic acid 5 cc. in excess. Dilute with water to 600 cc.). Redissolve the uranium in 50 cc. hot 1:3 H_2SO_4 by pouring the hot acid back and forth two or three times on the precipitate, catching the filtrate in a 400 cc. beaker.

Wash the filter paper about 30 times with dilute H_2SO_4 water. In high vanadium steel it is better to test for vanadium by adding 5 cc. of H_2O_2 to the solution and noticing whether it changes to brown; if it does, make another ammonium phosphate precipitation to remove the vanadium. If the solution does not change in color, bring it to a boil; then add several drops of $KMnO_4$ till it gets a pink color that will not fade after 15 min. boiling. Cool the oxidized solution to room temperature. Now reduce the uranium by passing it slowly through a zinc reductor and immediately titrate the reduced solution with a standard $KMnO_4$ solution to the first appearance of pink that spreads all through the solution. If there is any vanadium in the solution at this stage the pink will disappear in about 5 sec. instead of holding one minute. Any more permanganate added that disappears after 5 sec. standing is due to vanadium that has been carried over as phosphate.

Jones Reductor

The column of zinc in the reductor rests on a $\frac{3}{4}$-in. plug of glass wool. The zinc column is $5\frac{1}{2}$ in. long by $\frac{3}{4}$ in. in diameter consisting of 30 mesh grains of amalgamated zinc. The amalgamation is accomplished by stirring the 30 mesh zinc under a covering of mercuric chloride solution made by dissolving 50 g. of $HgCl_2$ in 1000 cc. of water. The zinc after amalgamation is washed with distilled water by decantation in a beaker until free of excess mercuric chloride, when it is ready for use.

A trap jar is placed between the filtering flask and the suction to prevent back pressure which would carry water over from the suction pump into the flask which holds the filtered, reduced, solution of uranium. The volume of the uranium solution to be reduced is about 50 cc. This is passed through reductor slowly, i.e., at the rate of 50 cc. per 10 minutes.

After passing the solution through the reductor, wash the zinc with dilute H_2SO_4 (1:6) three times, 10 cc. each time, and then three times more with 10 cc. of water each time; drawing off each washing completely before adding next washing. The volume before titrating is about 100 to 110 cc.

For convenient calculation 2.29 g. $KMnO_4$ are dissolved in distilled water and diluted to four liters.

1 cc. $KMnO_4$ Standard = 0.002169 gram U.

1 cc. $KMnO_4$ Standard = 0.001014 gram Fe.

The standard $KMnO_4$ can be checked for its uranium and iron value by titrating it against sodium oxalate.

Uranium in Chrome Tungsten Steel

Dissolve 5 g. of steel in 50 cc. of 1:3 H_2SO_4 diluted with 50 cc. of water; after action is over, filter off the insoluble residue and dilute the filtrate to about 250 cc. volume with water. Now add 1:1 ammonium with constant stirring until the precipitate at first takes a reddish tint, next changing to a blackish and finally to a bluish-whitish. At this stage add about 2 cc. of ammonia with stirring to complete the precipitation of all the uranium in the filtrate with only a small portion of the iron. Filter it off at once and finish as in plain uranium steel.

The insoluble tungsten and chromium carbide residue on the filter was found to contain some of the uranium. Wash it off the filter paper with dilute sulphuric acid into the original beaker, heat it, and then oxidize it with 30 cc. of 1.20 nitric acid. Keep on heating on a low flame until the residue is bright yellow. Filter off the tungsten, wash it about 25 times with dilute H_2SO_4 wash; and peroxidize the filtrate with sodium peroxide to separate the uranium from the iron. Catch the uranium filtrate from the main peroxidation and that from peroxidation of the insoluble residue in the same 800 cc. beaker and finish as in plain steel.

A variety of mixtures was tested by adding different portions of uranium acetate (56.13 per cent). The results are given below.

TABLE SHOWING URANIUM ADDED AND FOUND TO 10 GRAM SAMPLE OF PLAIN STEEL

Added Gram Uranium	Found Gram Uranium
0.0112	0.0119
0.0143	0.0143
0.0168	0.0169
0.0280	0.0286
0.0561	0.0573
0.0056	0.0055
0.0084	0.0085

Ten grams of plain carbon steel—no uranium added.
$KMnO_4$ 1.2 cc. reading of burette after titration.
$KMnO_4$ 0.0 cc. reading of burette before titration.

$KMnO_4$ 1.2 cc. = blank which is deducted.

Uranium, chromium and iron mixture; chromium added as $K_2Cr_2O_7$ to 10 gram sample of plain steel before dissolving same in H_2SO_4.

TABLE SHOWING URANIUM ADDED AND FOUND TO 10 GRAM SAMPLE OF STEEL

Added Gram	Found Gram
0.0056	0.0057
0.0084	0.0085
0.0280	0.0286
0.0561	0.0558

TABLE SHOWING URANIUM ADDED AND FOUND TO 5 GRAM SAMPLE OF TUNGSTEN, CHROME, VANADIUM STEEL

Added Gram	Found Gram
0.0112	0.0113
0.0280	0.0278
0.0561	0.0575

Five grams—no uranium added.
1.8 cc. reading of burette after titration.
0.0 cc. reading of burette before titration.

1.8 cc. = blank which is deducted.

About 80 per cent of the iron is removed by ammonia precipitation in the filtrate when large amounts of carbides of tungsten, chrome and vanadium are present, as was found by actual test. The bulk of the 20 per cent of iron that remains to be separated by peroxidation is found in the carbide residues of these steels.

Crucible Steel Co. of America.
Pittsburgh, Pa.

Continuous Distillation of Tar

According to *Commerce Reports*, May 6, the Hird process for the continuous distillation of tar is being used successfully in England, Japan and Australia, 130 plants having been erected at a cost of about $1,500,000. In England, this process is rapidly superseding all processes hitherto used.

Sintering Zinc Residues

A Description of One of the Methods Used by the Bartlesville Zinc Co. to Recover Values From Zinc Retort Residues—Most Excellent Blast-Furnace Material Containing Values in Gold, Silver and Lead Is Made From Oxidized Fines With No Fuel Additions

By K. STOCK

ZINC ores and concentrates from the Rocky Mountain region containing various amounts of lead, copper, gold and silver are treated at the zinc smelters of the American Metal Co., located at Bartlesville, Okla. After roasting and retorting in the usual way, all residues, now containing not more than about 6 per cent of their original zinc contents, are subjected to an additional treatment depending upon the amount and nature of other metals to be recovered. For instance, a residue low in gold and silver, when admixed with complex zinc-lead ores, is burned on a Wetherill grate to a discarded clinker and a valuable fume of lead sulphate and zinc oxide. Retort residues ("ashes," so called) higher in gold and silver are clinkered in heaps, after the Petraeus patents, producing a most excellent, porous blast-furnace material (Fig. 1) with no other fuel than the excess carbon remaining from the distillation.

Metal Losses

Residues are selected so that the resulting sinter shall have a lead content as much above 5 per cent as possible (even after a moderate volatilization loss during the operation), 5 per cent being the minimum limit for payment according to smelter schedules. Zinc burns off to a rather larger extent than does lead, but even so the clinker may run above 10 per cent at times and be assessed a corresponding penalty. Copper, gold and silver show virtually no losses unless large blowholes in the burning pile are left untended, when the silver values especially will show an unusual deficit. To be specific, a typical residue charged on a heap may be a mixture of Butte and Cœur d'Alene residues of the following compositions:

	Butte Residue Per Cent	Cœur d'Alene Residue Per Cent
Zn	10.2	7.5
Fe	7.2	11.0
Mn	0.7	0.4
Pb	4.7	9.0
Insoluble	30.0	27.5
Cu	0.6	0.2
Carbon	35.0	30.0
Ag	37 oz.	6 oz.

Typical Clinker Analysis

Such residues are mixed on a pile "as they come." Straight Butte residue is too low in lead for payment, while straight Cœur d'Alene residue has so much lead that it softens and does not sinter well. A typical clinker analyzes as follows:

	Per Cent		Per Cent
Zn	12.0	SiO_2	38.0
Fe	12.9	Cu	0.8
Mn	1.1	C	1.2
Pb	9.8	Ag	27 oz.

Naturally the clinker will vary considerably from these figures, depending upon the relative proportion of the main constituents which find their way into the bed.

Metallurgical balance sheets for a couple of years show the following losses:

	Per Cent		Per Cent
Shrinkage in weight	32.0	Pb	— 8.9
Au	— 2.8	Zn	—18.1
Ag	— 3.2	Fe	— 2.8
Cu	+ 1.4	Mn	— 7.2

Of these losses, those in silver, lead and zinc represent principally volatilization losses, while those of other metals are largely due to dusting and windage. Gain in copper is probably due to analytical errors (our residues ordinarily are quite low in this metal), while the figures for gold, iron and manganese are probably subjected to the same error, at least to as great an extent. Volatilization of a large percentage of zinc is naturally desirable, since we are making lead blast-furnace material, but an accompanying loss in lead and silver counteracts the gain.

During the operation the weight is diminished almost entirely by the elimination of carbon, so that 100 lb. of fine, bulky "ashes" will produce 68 lb. of scoria, as noted above.

Building the Kiln

The clinkering beds or "kilns" are each 47 to 50 ft. square at the bottom, and are ranged in a long row, skirted on one side by an air main and on the other by tracks for locomotive crane and railroad cars (Fig. 2). The site is prepared by carefully leveling the earth and building a series of air channels of loose brick, covering the area like a gridiron, as is sketched in Fig. 3, and shown in the foreground of Fig. 2. At the rear center of the pile a long-radius bend of 12-in. riveted pipe leads from the air main to a breeching built of brick or tile bats, cemented and covered with a fairly large mound of earth to prevent air-leakage or damage from clinker removal. This breeching divides the air

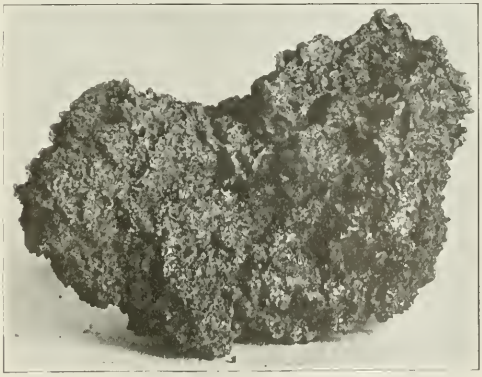


FIG. 1. TEXTURE OF CLINKER

FIG. 2. LOOKING DOWN A ROW OF CLINKERING BEDS

current into a header leading to right and left along the back of the pile and parallel to the air main, which header is constructed as follows: The central third is composed of two walls of closely dry-laid brick, four courses high and 4 in. apart, while the end portions are built but three courses high. The roof merely consists of square brick or tile closely laid to exclude infiltering fines. At intervals of 3½ ft. a half-brick is removed from the front wall, from which openings the minor channels lead clear across the pile toward the front. These channels, 13 in number, are somewhat similar to the headers; they are built of dry brickwork, the bottom courses consisting of half-bricks, however, while the top courses and roof are tight. This provides a great many relatively large openings through which the air blast may find its way out into the pile above. All these channels are then covered with a thin ridge of earth, patted down with a flat shovel, and the area is ready for ashes.

Two men are required to perform the work of smoothing down the ground, building and covering the air channels.

Retort residues are brought to the heaps either in the tram-cars which operate in the furnace cellars, or in standard gondolas. For the former, an elevated track traverses the site of several piles (Fig. 2); this track will probably be dismantled in favor of the practice to be immediately described, thus eliminating the work of two trammers. Railway cars, filled with residue ashes through traps, are switched to the site of a new pile, and approximately 100 tons are unloaded by locomotive crane and clam-shell bucket in a ridge at the rear of the pile, as shown in Fig. 4, covering the back header with the toe of the slope occupying the position a few feet beyond the channels sketched in Fig. 3. Two more carloads are piled along the front of the heap, thus leaving a trough across the area midway from front to back, where for a short distance all of the 13 parallel channels are yet uncovered.

When two more carloads of residue are spotted ready for this heap, an armful of coarse wood is deposited in the short valleys remaining exposed between air channels, a shovelful of hot coals placed on the wood, and the whole covered with residue from the adjoining slope. When a row of fires is kindled in this manner across the pile, a little air is admitted by raising the slide gate somewhat, and the locomotive crane proceeds to unload the two cars into the trough, finishing out a square pile which when trimmed off becomes about 5 ft. deep (Fig. 5). By this time the air gate is wide open, and the blast, working its way through the earth channel-coverings, fans the coals and kindlings into life; thence the combustion expands through the mass in all directions.

Within a few hours smoke begins to emerge from an area across the center of the pile, gradually widening as the fire works its way from the points of kindling. Within a week it has extended to the entire area of the pile, and the center, burning since the first, has sunken somewhat. This depression is kept level, however, by adding more ashes, in order that the resistance to escaping blast may be approximately the same in all parts. All burning piles are inspected several times each 24 hours, and any blowholes which may appear are smothered under a small heap of fresh residue. As combustion proceeds and the pile settles, a new carload of ashes is spread over the surface, this practice continuing until four to six extra carloads of residue have been added, making a total of 500 to 600 tons residue in one heap. Despite tight construction of the header, the rear portion of the pile burns more rapidly than the front, and consequently the unburned additions are spread much more liberally on this region, and the clinkered mass is deeper in consequence.

After about a month the pile has been built to its maximum depth and pretty thoroughly burned. Fire constantly breaks through at so many different places that one man spends the largest part of his time digging out the black sandy residue from unburned spots and heaping it over the tiny volcano craters. During this last stage, the surface of the pile becomes naturally very irregular (Fig. 6)—mounds cover these places where for some reason or other the blast was most effective,

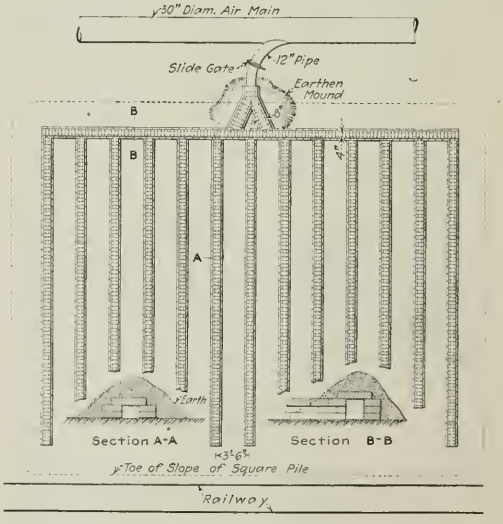


FIG. 3. PLAN OF CLINKERING HEAPS

FIG. 4. AIR CHANNELS COMPLETED AND FIRST CARLOAD OF RESIDUE UNLOADED

while other portions of the pile where little air penetrated are almost denuded of material. As the unburned cover becomes thinner the air supply is gradually reduced, and at the end of the operation the surface of the pile is a brownish granular mass, covering the sintered material to a depth of a couple of inches. This covering, although having lost the large part of its carbonaceous material, radiated its generated heat so rapidly that fusion was impossible.

For all work in trimming up the piles, five day men and one night man are employed. While actually on a burning pile, the workmen move about on short pieces of plank, so that their weight may not break through into an incandescent cavity, which sometimes exists several feet in diameter.

Loading Clinker

Burning a pile thus requires in the neighborhood of 35 days. When this stage is finished, the air is completely shut off, and a garden hose set so as to sprinkle water over the surface, wetting continuously for three days before the pile is cool enough to handle. Speedy cooling is of advantage further than as a time saver, since slowly cooled clinker is very tough, while quenched clinker breaks more easily. The pile now consists of a large thick clinker, more or less continuous, covered by a thin blanket of unconsolidated fines, but in all much too solid for removal by hand or machinery. Consequently the pile is broken up with powder.

A 2-in. bar is driven down to the ground level at intervals of about 5 ft. between each pair of air channels. On removal of the bar the hole is inspected, and if there is reason to suspect that the material at the bottom is not quite cold, water is hosed into it for some time. A line of cold holes is then loaded with a stick of dynamite in each, some fine material sifted in for tamping, and the charge fired with slow-burning fuse. The powder charge is naturally varied according to conditions—the idea being to lift the mass but slightly, cracking it into one-man size, without throwing even the fines more than a few feet. A crew of seven men then attack the broken pile with sledge, pick and shovel, moving the sinter a few feet to the rear on clean ground, separating out the earth covering from the air channels and reclaiming the brick.

FIG. 5. COMPLETED HEAP

A locomotive crane then loads this piled clinker by means of a clam-shell bucket and the area is ready for rebuilding the air channels. Unsuccessful trials demonstrated that this style of bucket, even when equipped with teeth, was totally unable to dig the pile after it had been broken up with powder. While an orange-peel bucket would doubtless handle such material, considerable time would be required to make the frequent changes in buckets, since this style is unsuitable for unloading cars, which, in fact, is the most essential part of the cranes' duties. Even so, digging by machine must stop at a level a few inches above the tops of the air channels in order to avoid loading a large tonnage of earth cover and bats, leaving the balance of the clean-up to be done by hand labor. Working on such a scheme the loss of time and inconvenience of changing buckets would tend to offset the hand digging saved.

FIG. 6. IRREGULAR SURFACE OF BURNED HEAP

A layout which would allow complete clean-up by clam-shell bucket would require a solid floor traversed by depressed air conduits and covered by a layer of refractory ore. Such a floor must resist the extremely high temperature generated during the sintering operation, and still be tough enough to resist the impact of a heavy bucket. A cyclopean sheet cast in large blocks each containing several tons of slowly cooled slag would most likely answer the requirements, but large quantities of molten slag are not obtainable at most zinc smelters. Slag brick, on the other hand, are notoriously unsatisfactory. Extra large vitrified paving block, well cemented, might serve, but would make a very expensive foundation. Any such scheme would further involve a plant cost which is entirely lacking and is the most attractive feature of the present installation, and would probably more than absorb the present labor costs in maintenance and capital charges. Should the present crane be crowded with work to a point where it could not load the rehandled clinker without overtime, a portable conveyor loader would be the logical machine to take the lumps direct from the pile into a gondola.

The sintering plant at Bartlesville comprises a long

row of 17 such "kilns," and ships from 40 to 45 carloads of blast-furnace material monthly—approximately 2100 tons. The daily cost of operation is approximately as follows:

Labor:		
Day foreman and engineer	$4.00	
Night engineer	3.50	
Powderman	3.50	
2 Trammers	6.00	
6 Spreaders	18.00	
7 Diggers	21.00	
2 Men on air channels	6.00	
Total labor		$62.00
Crane:		
Engineer	$6.75	
Fireman	3.25	
Helper	3.00	
Upkeep of crane	25.00	
Cost of crane per day	$38.00	
Crane is busy 33 per cent of its time on this work		13.00
Power		6.00
Switching ashes		10.00
Powder, small tools and miscellaneous supplies		6.00
Superintendence and general charges		10.00
Total daily cost		$107.00

This figures to $1.53 per ton of clinker produced, and in any case should be less than the saving in freight on clinker as compared with crude residue between zinc plant and lead smelter, plus the cost of sintering green residue in a mechanical roaster at the latter place. An additional tangible advantage whose monetary value is difficult to assess lies in the fact that the clinker thus produced is a much more desirable blast-furnace charge from the physical standpoint than ordinary calcine, being quite strong and coherent, yet porous, and containing less than 15 per cent fines (Fig. 7).

General Considerations

Many different kinds of residues have been satisfactorily sintered at the Bartlesville plant in this manner. Apparently lead cannot be too low to prevent clinkering, since in any residue yet tried at this plant there is enough iron and lime either in the original ore or in the fuel ash to properly bind the mass together.

FIG. 7. PILE OF CLINKER READY FOR SHIPMENT TO BLAST-FURNACE

Indeed, a residue containing 10 per cent lead or more is very difficult to sinter, since it melts so easily, becoming viscid, compacting together and obstructing the air blast.

It has been found that a large volume of low-pressure blast is much better than a smaller quantity of air at high pressure. The latter gives a glassy non-porous clinker, through which the air breaks into blowholes or intensely heated craters from which high losses in lead and silver occur. The pile is unevenly burned, poorly agglomerated and high in carbon. For blast purposes we use a No. 10 Sturtevant blower, belt-connected to a 50-hp. gas engine, discharging into a long air main tapering from 30 in. to 18 in. at the extreme end. It has also been found that the distance center to center of air channels has an important effect upon the resulting coke—if they are much beyond 4 ft. apart the material at the bottom of the piles is not coherent, while deep troughs often have to be dug in unburned material above these regions toward the end of the burning stage.

Bartlesville Zinc Co.,
Bartlesville, Okla.

Removal of Limitations on Export of Silver

On Aug. 15, 1918, the Federal Reserve Board announced that licenses for the export of silver would thereafter be granted only for civil or military purposes of importance in connection with the prosecution of the war and only in cases where the exporter certified that the silver to be exported had been purchased at a price which did not directly or indirectly exceed $1.01½ per oz. one thousand fine at the point where silver is refined in the case of silver refined in the United States or at the point of importation in the case of imported silver.

The occasion which required the above limitations on the export of silver having now passed, the Federal Reserve Board will hereafter, unless a governmental necessity should again arise, resume its former policy of granting freely and without condition all applications for the export of silver bullion or of silver coin of foreign mintage.

This change of the policy of granting licenses does not do away with the necessity of filing an application for licenses to export silver bullion or silver coin of foreign mintage. Such applications must, as heretofore, be filed through the Federal Reserve Bank of the appropriate district, but such applications will, as stated above, be freely granted by the Federal Reserve Board.

The Secretary of the Treasury does not contemplate any further sales of silver under the Pittman act, except to the Director of the Mint.

Research Fellowships at University of Idaho

In co-operation with the United States Bureau of Mines and the Idaho Bureau of Mines and Geology, the University of Idaho offers in the School of Mines a number of fellowships. These fellowships are open to college graduates who have had good training in mining, metallurgy or chemistry and who are qualified to undertake research work. The income of each fellowship is $720 a year for the twelve months beginning July 1, 1919.

For 1919-20 the following subjects are being considered:

(1) Flotation—with especial reference to differential separation of various minerals.
(2) Availability of Western wood oils for flotation purposes.
(3) Treatment of the complex gold-silver ores of southern Idaho.
(4) Ore dressing problems.
(5) Mining problems.

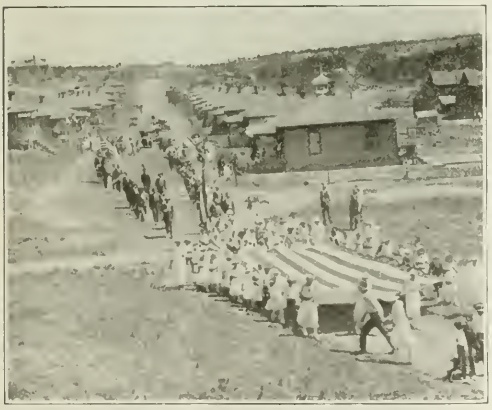
Applications, with certified copy of collegiate record, statement of professional experience, and names and addresses of three references, will be received up to June 1, 1919. The applications should be addressed to the Dean, School of Mines, Moscow, Idaho.

Americanization Work by the Colorado Fuel & Iron Co.

THE TRANSFORMATION of an alien immigrant into a useful American citizen is not completed when he has been taught to speak the English language. Recent events give ample evidence that some of the men who speak English most fluently—and most volubly—in public and in private are about the worst of Americans. On the other hand, ample proof of patriotism has been given time and again by foreign workmen whose knowledge of English is extremely limited. No one should attempt to belittle the importance of instruction in the English language. There is danger, however, that some will consider this instruction the chief end and aim in the Americanization of our alien workmen.

The Colorado Fuel & Iron Co. has about 12,000 employees, of whom the majority are of foreign birth or parentage. In 1916, after a survey of the company's steel works and mining camps by Dr. Peter Roberts, Immigration Secretary of the International Y. M. C. A. Committee, instruction in English was begun for the benefit of those workmen unfamiliar with the language of their adopted country. This instruction has since been carried on principally by the Y. M. C. A. secretaries who are in charge of the clubhouses at the various properties of the company. The instructors have proven energetic and efficient, and good progress has been made by pupils of various ages and different nationalities.

After the entrance of the United States into the war the company and the Y. M. C. A. received the hearty cooperation and assistance of Mr. J. C. Stephens, Director of the Committee on Americanization, Colorado State Council of Defense. Under his guidance it is expected that progress in the teaching of English and in preparing foreign workmen for citizenship will be even more rapid than before. In its endeavors to make good American citizens out of its alien workmen, however, the Colorado Fuel & Iron Co. has laid principal stress upon factors which it believes to be even more fundamental than instruction in English. The Italian, Greek or Slav, transplanted into a mining camp or a steel plant, if left to himself, is tolerably certain to acquire a smattering of English. What is less certain, however, is that he will at the same time learn American principles of government and American standards of living. The proverbial—and generally mythical—miner who stores coal in his bathtub is in need of something more than instruction in the English language. It is necessary that he be taught the principles of our system of government and what it stands for.



PATRIOTIC PARADE OF COLORADO FUEL & IRON CO. MINERS

The Colorado Fuel & Iron Co. is endeavoring to meet the needs of education in American ideas of government and standards of living through a careful fostering of community spirit and through a program of social and industrial betterment. This work is founded upon the Industrial Representation Plan—the so-called Rockefeller Plan—under which all employees deal with the company through representatives elected from among their own number. Through the constant application of industrial democracy, it is believed that sound principles of political democracy will be engendered.

DOMESTIC SCIENCE CLASS IN PUBLIC SCHOOL IN A COLORADO FUEL & IRON CO. CAMP

By means of the activities of the Y. M. C. A. and the social and industrial betterment work carried on by the company, different races and nationalities are brought into social intercourse and fellowship. This has been found beneficial to the workmen and the employer and doubtless tends to increase loyalty to American institutions. High wages, modern housing and the teaching of housekeeping have gone far toward establishing American standards of living. In the public schools in the various communities the children of employees of all nationalities are brought into contact with the English language and American ideals. At one of the schools a number of years ago a plan was inaugurated of giving the children credit for the work they did at home in teaching their parents the English language and subjects relating to American citizenship.

Since the United States entered the war against Germany, patriotism has been taught forcibly and directly to the employees. Encouragement has been given to enlistment in the Army and Navy and to contribution to the various loans and war funds. The result of this encouragement has been exceedingly gratifying and leads officers of the company to believe that the lessons in citizenship taught in the past have borne abundant fruit.

Metallic Coatings for Rust-Proofing Iron and Steel—II

Metallography of Zinc Coating—Variation in Structure of Hot-Dipped, Sherardized, Sprayed and Plated Galvanized Products—Significance of Structures—Methods of Preparing Surfaces for Coating and Their Effects Upon the Mechanical Properties of Steel—Bibliography

By HENRY S. RAWDON[1], M. A. GROSSMAN[2] and A. N. FINN[3]

MOST of the metals used for covering iron and steel as a preventive of corrosion form coatings which are very simple in structure. The metal alloys with the iron of the base to such a slight extent that no change in the microstructure of the resulting coating can be detected, and, in all probability, the behavior of the coating in resisting corrosion is not affected to an appreciable extent. With zinc, however, the case is quite different (15, 16, 18, 21, 23)—particularly is this so in the coatings which are by the application of heat. The zinc alloys with the iron to such a degree that the coating is relatively complex in structure and the properties of such coatings are very appreciably affected. In some coatings (52) certain of the microstructural constituents present may actually accelerate the attack of the metal which the coating is aimed to protect, and the technical literature contains various misleading statements (21) which if correct would suggest that a similar condition may exist in certain classes of zinc coatings.

Theoretical Microstructure of Zinc Coatings

In at least two of the four types, the coating is far from being a simple layer of zinc superimposed upon the base metal beneath, but is a rather complex one, composed of alloys of iron and zinc of various compositions. In order to understand properly the formation of these alloys and their composition, and for purpose of reference, the constitutional diagram of the iron-zinc alloys as modified by Raydt and Tammann (17) is included herewith.

Alloys with an iron content of more than 25 atomic per cent (22 per cent by weight) are formed only with difficulty, usually by melting the constituents under pressure; hence, a structure corresponding to an iron content beyond this point may be disregarded in the discussion of zinc coatings. The constitutional diagram shows four structural fields or layers which are possible in a coating which is allowed to come to equilibrium with the iron base. These are, (1) an outer one (m) of zinc containing a small percentage of iron in solid solution (about 0.7 per cent); (2) a duplex one (m . . . n) composed of a matrix similar to 1 in which are embedded particles of n (a solid solution of a chemical compound $FeZn_7$ with some zinc); (3) a layer composed entirely of the solid solution n, and (4) a duplex layer of two definite chemical compounds $FeZn_7$ and $FeZn_3$—the amount of each compound varies in this field from pure $FeZn_7$ on one side to $FeZn_3$ on the other.

The variations in structure corresponding to the different fields of the structural diagram are illustrated in Fig. 2, which shows portions of the coating produced on an iron wire (16 B. & S. gage) embedded in a block of zinc about $\frac{3}{8}$ in. (1 cm.) square in section by heating for 4 hours slightly above the melting point of zinc (approx. 450 deg. C.). Iron from the wire permeated throughout the zinc block so the resulting coating includes practically the entire block.

Adjacent to the iron is a thin layer, B, of intermetallic compound $FeZn_3$; just outside of this, a much thicker layer, B', in which the definite form of the crystals is plainly seen (this probably contains both $FeZn_3$ and $FeZn_7$); a very thick layer, C, consisting of tiny crystals of the compound $FeZn_7$ in a softer matrix comprises by far the greater part of the coating; the crystals in the outer margin of this layer are particularly well formed and much larger than the average throughout the layer. The outermost portion, D, of the coating shows the characteristic etch-markings of "pure" zinc; these are probably of the nature of Neumann lines; the metal here shows only a few traces of the second constituents; it undoubtedly contains iron, in solid solution, up to its saturation point (0.7 per cent). The nature of the various layers and their behavior during corrosion is discussed below.

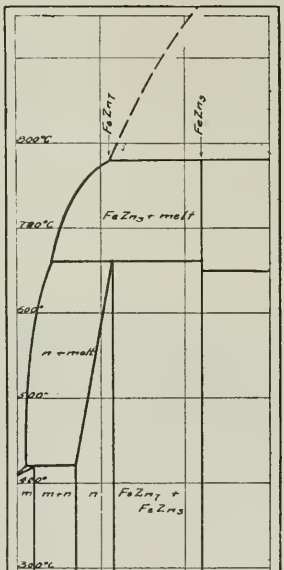


FIG. 1. PORTION OF THE CONSTITUTIONAL DIAGRAM OF THE ZINC-IRON ALLOYS

Variations in Microstructure of Commercial Coatings

a. Hot-Dipped Materials. The variations in structure of this type of coating which may arise in practice are best shown by comparison with the structure when equilibrium is reached, as described above. In general, the same layers are formed in each specimen of this type; the relative amount of each constituent, however, varies considerably according to the conditions of dipping. Fig. 3a shows the structure of a thin coating of this type (galvanized sheet; described by manufacturers as having 1.37 oz. of zinc per sq.ft., i.e., 0.68 oz.

[1]Associate Physicist (Metallography), Bureau of Standards.
[2]Metallographist, Vanadium Co. of America.
[3]Associate Chemist, Bureau of Standards.

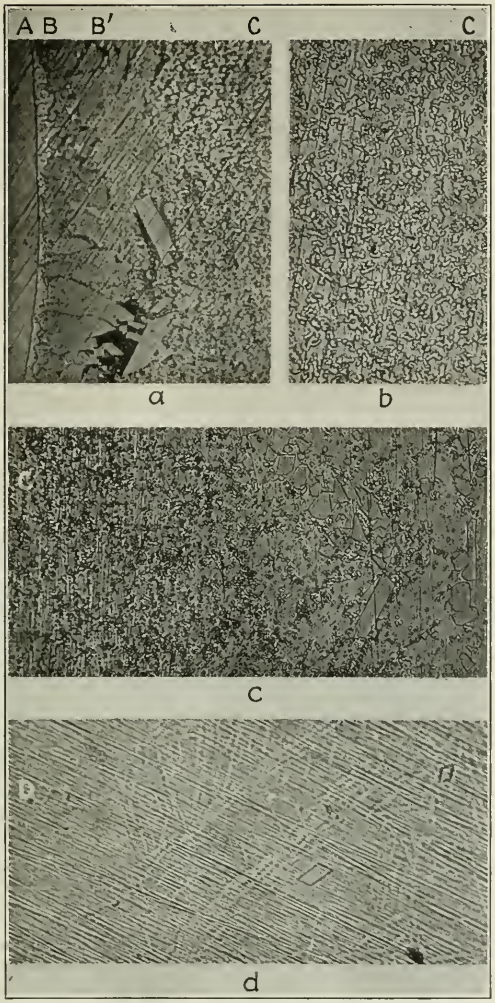


FIG. 2. MICROSTRUCTURE OF ZINC COATING FORMED ON AN IRON WIRE IMMERSED IN MOLTEN ZINC FOR FOUR HOURS

a: *A*. Iron wire. *B*. Alloy layer, $FeZn_3$, adjacent to the steel base. B^1. Layer of the compound $FeZn_7$ (with perhaps some $FeZn_3$). *C*. Duplex layer of crystals of $FeZn_7$ embedded in a softer matrix of zinc containing some iron in solution. × 500. *b*: Intermediate portion of layer *C*. × 500. *c*: Outer portion of layer *C*: the crystals of $FeZn_7$ in the outer portion are large and well formed. × 200. *d*: Outer layer of zinc (containing some iron in solution). The shadow-like etch markings are rather characteristics of zinc. × 200. Etching: 1 per cent. iodine in alcohol was used throughout and for the remaining samples unless stated otherwise.

per sq.ft. on each side). A very thin innermost layer of $FeZn_7$ is to be seen of approximately the same thickness as in the heavy coating (Fig. 3b), which contains 2.5 oz. of zinc per sq.ft. (1.25 oz. per sq.ft. each side). Inasmuch as the thickness of the commercial coating is ordinarily controlled by mechanically adjusting the height of the molten bath relative to the guiding rollers and not by increasing the period of immersion in the zinc, it is to be expected that such would be the case. Fig. 4 shows this innermost layer in a very oblique section of a coating. By holding the article to be coated for a much longer period in the molten zinc, this layer is given a chance to increase considerably in thickness, as is shown in Figs. 5a and 5b, which represents a sample held for approximately eight times as long in the bath as is considered good commercial practice, and a sample which was run through the bath several times in succession.

The intermediate alloy layer appears to be of approximately the same thickness in both the thinly and thickly coated commercial sheets, the difference in the weight of the coating being due to an increase of the outer zinc-rich layers in the thicker coating. (The removal of the excess outer zinc-rich layer in the thin coatings does not allow the crystals of the intermediate alloy layer to form as perfectly as is the case in the thick coatings.) By lengthening the time the molten zinc is in contact with the iron base the relative thickness of the alloy layers is increased—this will be accompanied by a corresponding decrease in the outer zinc-rich layers, particularly in the coatings of sheets and wires, in which the thickness is kept fairly uniform by some mechanical means. The

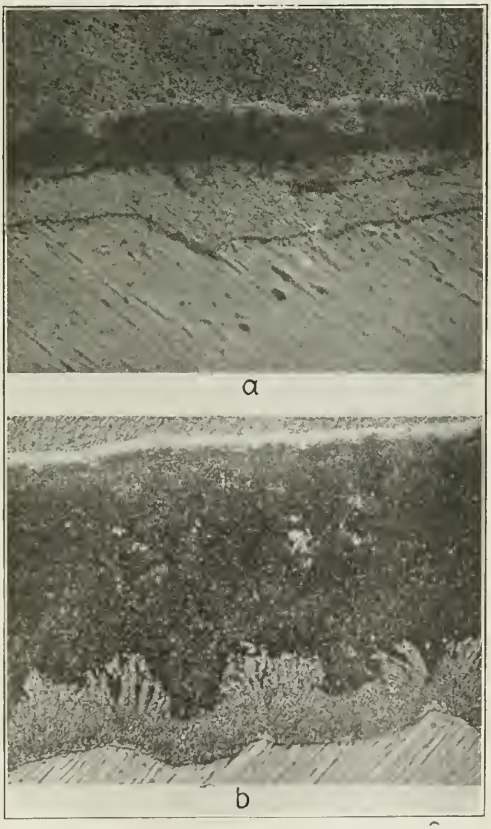


FIG. 3. COMMERCIAL HOT-DIPPED ZINC COATED SHEETS

a: Thin coating; average weight of coating as determined by weighing the sheet before and after dipping 1.37 oz. per sq.ft. *b*: Thick coating; average weight, 2.5 oz. per sq.ft. × 500. All micrographs are arranged (here and following figures) so that the alloy, or inner, layer is toward the bottom of the page.

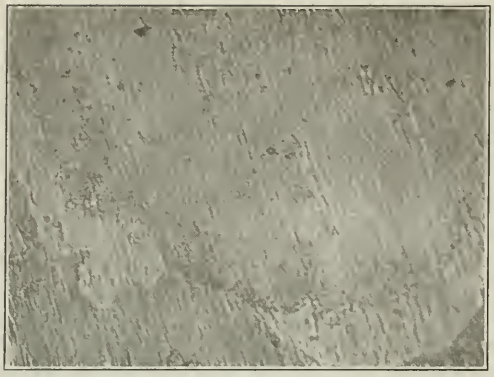


FIG. 4. COMMERCIAL HOT-DIPPED ZINC COATED SHEETS
Oblique section of material of *b*, Fig. 3, showing the inner layers of $FeZn_8$ (white). × 500.

significance of these alloy layers in service is indicated later in this article. The sheets which were held for a considerable length of time in the molten zinc were found, after standing about two weeks, to be spotted with numerous exudations (Fig. 6b). There is nothing in the microstructure to account for this other than some tiny pockets which were apparently filled with inclusions of the zinc and ammonium chloride flux from the bath and which, under the influence of atmospheric moisture, swelled and exuded out of the coatings.

Whether such inclusions of the flux will materially affect the life in service of such coated sheets cannot be stated with certainty from a study of the structure alone. Most of the pits and inclusions, however, appear to be in the outer layers of the coating, and not between the base metal and the coating.

b. Sherardized Coatings. In coatings of this type it is only in those of considerable thickness that any definiteness of structure appears. Figs. 7 and 8 show the structural features which may be expected to occur in coatings of this type.

The nature and composition of zinc-dust mixtures in which the articles are packed for heating probably determines almost entirely the nature of the outer layer; in the innermost layers alloying with the iron base occurs. The outer portions have a characteristic rough and porous appearance and contain a considerable number of inclusions of oxide and any foreign ingredients which may be present in the heating mixture.

The inner portion of this outer layer is much denser than that near the outer surface and has a very characteristic appearance, being broken up by many fine intersecting cracks, caused probably by contraction upon cooling. The layer probably contains a considerable amount of the compound FeZn$_7$. The intermediate layer (Fig. 8b), which easily etches dark, in all probability marks the outer limit of the pronounced alloying of the iron of the base with the zinc of the coating. An extremely thin layer immediately adjacent to the iron base, and apparently of the compound $FeZn_7$, marks the union of the coating with the base metal. In none except very thick ones, e.g., 0.008 in., are these two innermost layers usually found; when much thinner, e.g., 0.002 in. or 0.0015 in., the coating consists entirely of what, in the thicker ones, constitutes the outer layer.

c. Sprayed Coatings (12,13). The variations noted in this type of coatings are of a mechanical origin, due to the nature of the method of deposition, rather than to any alloying of the zinc with the iron base. In Fig. 9 are shown cross-sections of two sheets coated by this process. The coating designated as "one spray" is very irregular and extremely thin in spots. The second sample was described by the manufacturers as a "four spray" coat, but the structure suggests that a coating somewhat heavier than this was applied. The distinct lamellæ which comprise the coat are due to the additional layers of zinc superimposed upon the earlier ones, with some accompanying oxide. Similar features are shown by "sprayed" coatings of other metals.

d. Plated Zinc Coatings. As is to be expected from the nature of the process by which such coatings are deposited, they are essentially of pure zinc and show none of the different alloy layers seen in the first two types. Fig. 10 shows a coating of electrolytic zinc, deeply etched. No indications of structural variations across the section of the layer are to be seen.

The principal point of interest in connection with the microstructure of this type is the variation in

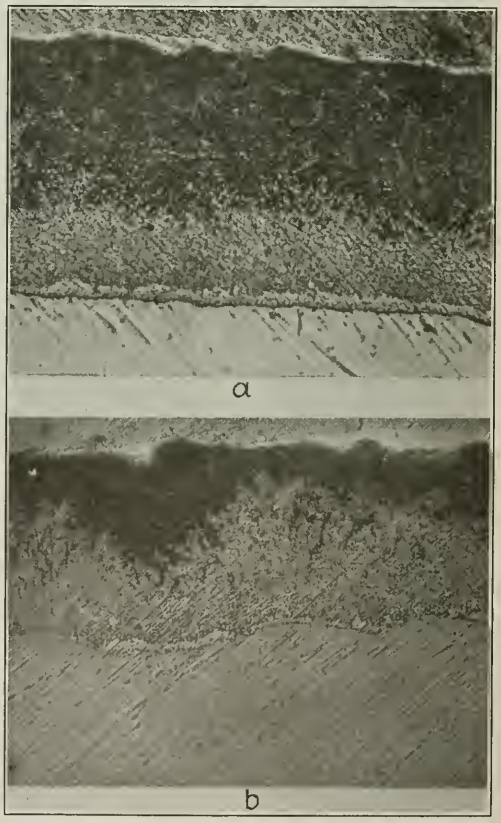


FIG. 5. COMMERCIAL HOT-DIPPED ZINC COATED SHEETS
These were produced under unusual conditions. *a:* Material similar to that of Fig. 3 which was held stationary in the molten bath for two minutes. *b:* Material similar to *a* re-run through the molten bath four times. The alloy layers have been much accentuated by these treatments. × 500.

thickness which may exist on irregularly shaped pieces or even on flat surfaces. Such variations are to be found, particularly in depressions, and on sharp projections where the differences in the current density are considerable. This is especially true for the threaded portion of bolts and screws.

A set of measurements on two similar small machine bolts plated under identical conditions for different periods of time gave the following results:

Weight of Coating Computed From Tank Conditions	Average Thickness, Top of Thread	Average Thickness at Root of Thread
0.20 oz./sq.ft.	0.0157 mm.	0.0038 mm.
0.55 oz./sq.ft.	0.0224 mm.	0.0053 mm.

Fig. 11 shows the variation in thickness of coating on a small article having several sharp corners. The rivet is shown natural size; the thickness of the coating has been magnified approximately 200 times.

Even on flat surfaces the coating is not of uniform thickness. Fig. 12 shows a series of thickness measurements made on sections of a plate 4 in. square, which had been electroplated under very carefully controlled commercial conditions. The sections were cut $\frac{1}{2}$ in. apart, the longer one being taken along a diagonal of the plate. The plate is shown natural size, the relative thickness of the coating has been magnified as indicated. The features described above for electrolytic zinc coatings may be taken as typical of coatings of other metals electrolytically deposited. The microstructure of electrodeposited coatings depends almost entirely upon the conditions of plating, composition and concentration of solutions, etc. (14, 19). Fig. 13 may be considered typical of a normal deposit of electrolytic copper from the commonly used acid-sulphate bath. The variations in thickness of such coatings in very deep, sharp grooves is shown in Fig. 13b. Fig. 14 shows the structure of the copper-clad steel described in the first section of this article.[1] A very thin but definite intermediate alloy layer has formed between the two metals.

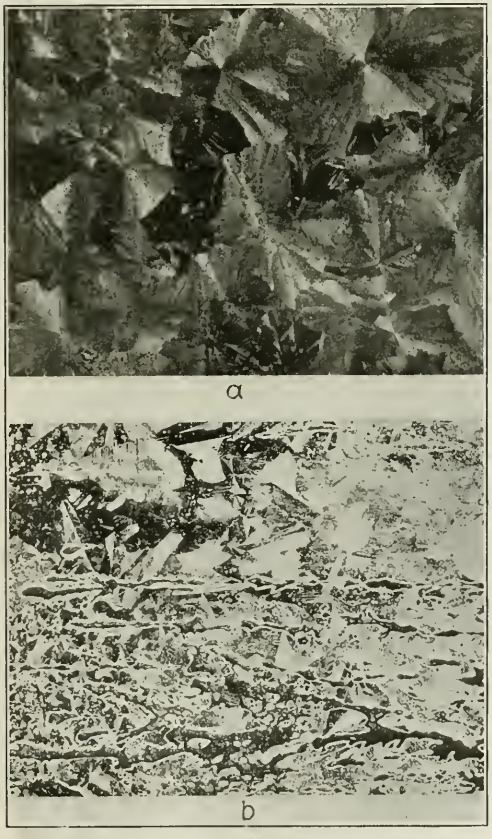


FIG. 6. SURFACE APPEARANCE OF HOT-DIPPED SHEETS
a: Usual appearance. *b:* Appearance of the material of Fig. 5. Upon standing the surface became covered with spots of flux which exuded from within the coating. Natural size.

FIG. 7. STRUCTURE OF SHERARDIZED COATINGS
Oblique section of a coating averaging 0.008 in. in thickness. × 100. *A:* Decarburized surface of the steel plate. *B:* Inner layer of coating. (Probably contains $FeZn_5$.) *C:* Intermediate fissured layer of the coating. ($FeZn_7$?) *D:* Roughened outer surface.

Significance of Structure of Coatings

Metallic coatings may protect the metal which they cover in different ways; all coatings afford a mechanical protection against moisture and other corroding agencies. Some metal coatings also by their greater solubility than the base metal protect the metal beneath from corrosion in a chemical way. As previously stated, of the common metals used for coatings, zinc is the only one which behaves in this manner. The significance of the various structures which may occur in different types of coatings should be considered with reference to the bearing they may have upon these two functions which the coating has to perform.

[1] CHEM. & MET. ENG., Vol. 20, No. 9, p. 460.

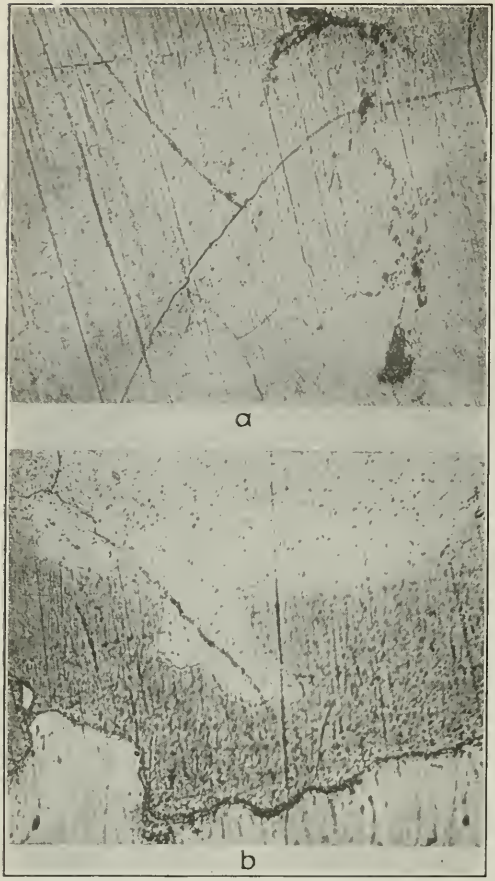


FIG. 8. SHERARDIZED MATERIAL
a: Section of intermediate layer, showing the network of fine cracks and some of the inclusions retained from the heating mixture. *b:* Inner layer, which probably represents the extent of the pronounced outward alloying action of the iron—a very thin film of the compound, presumably $FeZn_7$, lies immediately adjacent to the iron base. × 500.

Various conflicting statements have appeared in the literature concerning the relative electrolytic solution potentials of the different zinc-iron alloys, particularly those which occur in galvanized coatings. The behavior of the alloy layers upon etching indicates that they are electro-negative toward the zinc, i.e., they bear the same general relation to zinc in this respect that iron does. Further than this cannot be stated with certainty from an examination of the microstructure above. Guertler (21) states that the innermost layer ($FeZn_7$) is also more electro-negative to the zinc than is iron, and hence iron will be electro-positive to such a layer; so that when both are exposed to the corroding influences, by the wearing away of the outer layers by mechanical injury, etc., corrosion of the iron will be accelerated by the inner layers. Others have apparently reiterated Guertler's statement, though some have later corrected such statements. The diagram below is constructed from the e.m.f. measurements of the system $Zn - \frac{N}{20}\ ZnSO_4 -$ FeZn alloys (20) and shows that all the alloys behave toward iron in the same general manner as does pure zinc, though not to the same degree. .

Although both of the compounds, $FeZn_7$ and $FeZn_2$, are electro-negative toward zinc, and so will aid in the solution of the zinc when either one is exposed to the corroding agency along with the zinc, it appears that such action is not serious and may safely be disregarded. Fig. 16 shows a section of the coating on hot-dipped galvanized sheet on the exposed and unexposed sides after more than 30 years of service.

The intermediate alloy layer in this material was remarkably well developed—the section of the exposed surface shows that the coating has been quite uniformly corroded away and at the point where the section was taken the inner strata of the alloy layer still remained intact. The claim has been made that zinc coatings containing as large a percentage of the alloy layer as consistent with the mechanical properties desired (freedom from flaking on bending, etc.) are very desirable (35). On account of the lower potential difference between iron and the zinc-iron alloys as compared with that between iron and the pure zinc, those coatings containing the excess of the alloys might be expected to have the longer life in service. Such coatings will, however, not be able to exert protective influence over as large bare spots as will those of much purer zinc.

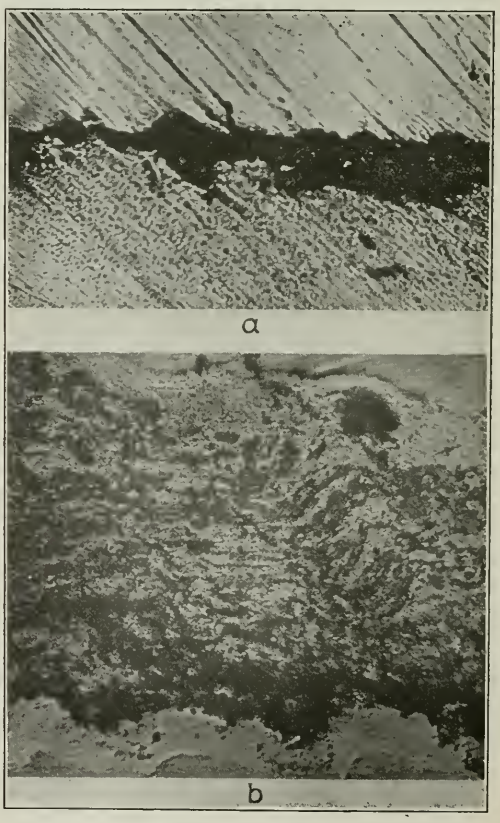


FIG. 9. CROSS-SECTION OF "SPRAYED" ZINC COATING
a: "One spray" coat. *b:* "Four spray" coat. × 500.

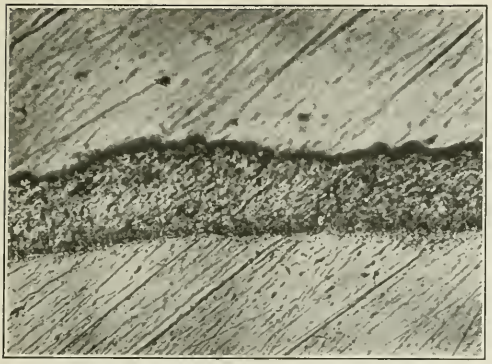


FIG. 10. CROSS-SECTION OF ELECTROLYTIC ZINC COATING, DEEPLY ETCHED WITH 10 PER CENT SODIUM HYDROXIDE. × 500

Inasmuch as these alloy layers are never found in two of the other types, the sprayed and the electrodeposited, the resistance to corrosion of articles covered with such coatings depends entirely upon the thickness of such coatings and on the uniformity of the coating. The variations which may be expected in this feature of these two types of coatings have been discussed above.

Like most intermetallic compounds, the layers of $FeZn_7$ and $FeZn_2$ are relatively hard and brittle. The compound $FeZn_2$ appears to be considerably harder than is the other compound, so that coatings in which it is well developed are easily separated from the base metal, by sharp bending. The fine crystalline condition of the electrolytic and the sprayed coatings probably exerts

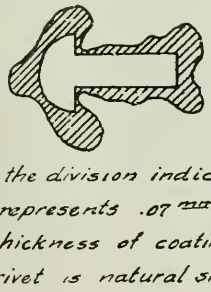


FIG. 11. VARIATION IN THICKNESS OF THE ZINC COATING (ELECTROLYTIC) ON AN OBJECT HAVING SHARP ANGLES

as great an influence as does the absence of any brittle layers in such coatings in preventing them from stripping loose from the base metal as is the case in thick coatings of the hot-dipped type.

Preparation of the Surface Before Coating and Accompanying Effects Upon the Mechanical Properties of Steel

The successful application of coatings to steel requires that the surface of the specimen shall be clean, i.e., free from all oxide and non-metallic material. The general methods of cleaning are: the chemical (63, 64), in which the scale is removed by a direct chemical process of solution; the electrolytic (62, 66), in which the material is made anode or cathode in an electrolytic bath; and the mechanical, in which the scale is removed by abrasion, such as sand blast, tumbling, etc.

The most widely used cleaning process is a chemical one—it is the process of "pickling" in sulphuric acid. It has the advantages of being rapid and inexpensive, of reaching all parts of irregular specimens and of being readily handled by inexperienced operators. In general, the samples are immersed for from 5 to 30 minutes in sulphuric acid of concentration 2 to 15 per cent by weight and at temperatures from 25 to 60 deg. C. Other reagents for pickling include hydrochloric acid, hydrofluoric acid (which is especially useful for cleaning sand castings) and solutions of sodium acid sulphate.

The chief disadvantages of pickling processes are (1) that when the thickness of the scale is not uniform over a specimen, the steel at cleaned portions remains exposed to the action of the acid until the last of the scale is removed from other portions (65), and (2) that there is a skin effect, causing brittleness, which becomes quite pronounced on thin specimens. This brittleness is generally presumed to be due to surface absorption of hydrogen (60, 61).

Experiments have been conducted at the Bureau with

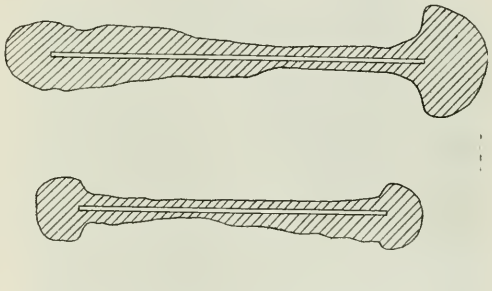


FIG. 12. VARIATION IN THICKNESS OF THE ZINC COATING (ELECTROLYTIC) WHICH MAY OCCUR ON FLAT SHEETS

a view to determining the conditions in the pickling operation that tend to increase brittleness. In a preliminary series of tests on $\frac{3}{16}$-in. wires, specimens variously treated were tested in tension, and the change in percentage elongation taken as a measure of the embrittling effect. The results of these tests seem to indicate that the temperature of the pickling bath has but little influence. Increase of the concentration of the acid increases the brittleness, as does also a longer

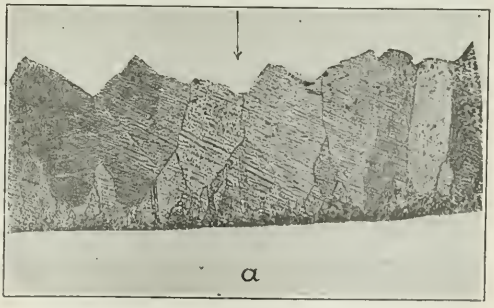


FIG. 13. ELECTROLYTIC COPPER DEPOSITS

a: Cross-section of a deposit on a flat surface, plated from a sulphuric acid-copper sulphate bath with relatively low current density.

FIG. 13B. ELECTROLYTIC COPPER DEPOSIT

b: Same type of deposit as in Fig. 13 within a narrow V-groove. The arrow indicates the side from which the metal was deposited. × 500. Etching concentrated ammonium hydroxide and hydrogen peroxide.

immersion period. Heating the samples as in sherardizing (375 deg. C. for 4 hours) removes the embrittling effect. Heating as in hot galvanizing (450 deg. C. for 2 minutes, though 2 minutes is considerably longer than the average practice) partially removes the brittleness. It has been stated that heating at 225 deg. C. for 6 hours removes the embrittling effect altogether. Further experiments are in progress at the Bureau, in which wires are being treated by various methods and then tested in impact and alternating stress.

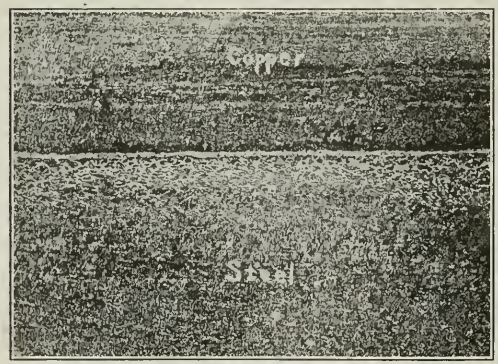


FIG. 14. COPPER-CLAD STEEL

A definite alloy layer has formed between the two metals. × 500. Etched with concentrated ammonium hydroxide followed by a 2 per cent nitric acid.

In the electrolytic method of pickling (62, 66), the sample is placed as cathode or anode in an electrolyte through which a current is passed. When the steel is the cathode, the hydrogen liberated there reduces some of the oxide scale and also aids mechanically in flaking off much of it; when the steel is the anode, the

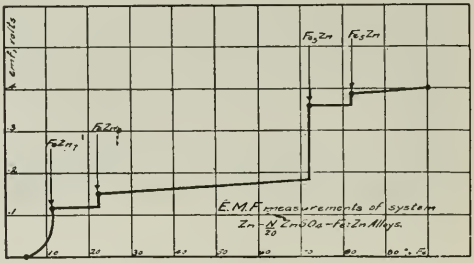


FIG. 15. E.M.F. MEASUREMENTS OF THE SYSTEM Zn — $\frac{N}{20}$ $ZnSO_4$ — FeZn ALLOYS

oxygen there liberated mechanically detaches the scale, which later may dissolve in the electrolyte. The concentration of hydrogen at the cathode would be expected to cause more brittleness, as compared with the anode, and experiments made elsewhere have shown that samples cleaned at the anode are much less brittle (61).

Of the mechanical methods of cleaning, the sand blast is the one most widely used. The strong stream of sand particles abrades or chips off the particles of scale

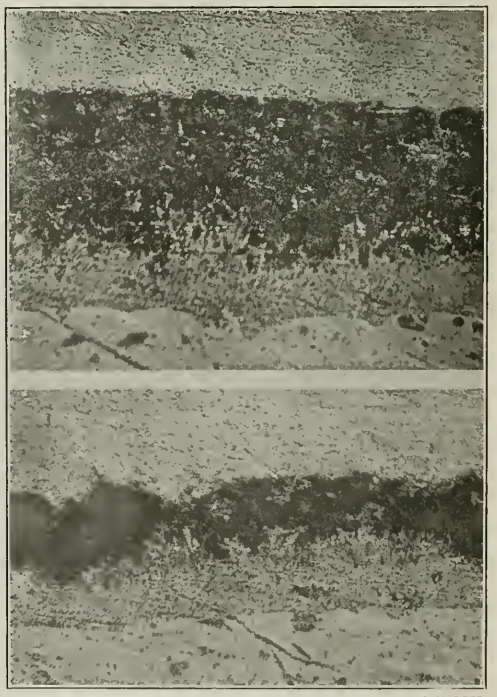


FIG. 16. STRUCTURE OF HOT-DIPPED SHEET WHICH STOOD MORE THAN 30 YEARS' SERVICE

Above: Coating from the inner or unexposed surface. Below: Coating from the outer or exposed surface. × 500.

from the steel. The method gives a smooth, bright surface, but takes more time than pickling and does not satisfactorily reach crevices. Steel shot and crushed steel are said to have some advantages over sand. It must be remembered that the "cold-work" of impact will cause hardening of the surface, which may be quite noticeable on thin sections and sometimes quite harmful.

Another process of mechanical cleaning consists in "tumbling" the specimens in a rotating barrel, with emery and water. It is an abrasion process. A similar method, used on small articles, involves rolling with emery and oil, between rollers. It is the mildest process of mechanical cleaning, and while quite slow it has advantages for springs and the like, in that it avoids both the brittleness from pickling and the hardening from the sand blast.

Hand Device for Flotation Experiments*

By Will H. Coghill
Metallurgist of the Bureau of Mines

In flotation experiments it is desirable to have a hand device correlating successively with the experimental and commercial machines. This phase of flotation has not been sufficiently developed. It is the purpose of this paper to describe a device which is intended to fill this gap.

Success in designing a machine depends upon the principles selected to govern its detail. The principles laid down to guide in the selection of this device are: The pulp density, and the ratio of solids to frothing surface, must be the same as in well designed machines.

The importance of these factors can best be emphasized by quoting from Del Mar.[1]

"Under manipulation may be included the shape or form of the collecting-chamber of the flotation machine, for the cells in any flotation system are used for two purposes, either to float a dirty concentrate, which must be cleaned before marketing, or to float a finished concentrate, which is ready for shipment. In the former case the collecting chamber of the machine should favor a quick discharge, that is, there should be a narrow chamber, but when we require a finished product the box must be sufficiently wide to allow the settlement of occluded waste or gangue. Manufacturers of flotation machines miss this point and therefore the same machine is often used for roughing and for cleaning, while the two operations require entirely different manipulation. This important structural feature in the flotation-chamber may make the difference between success and failure, for not only must a concentrate be produced, but it must attain a certain grade of metallic content to be fit for shipment."

Consistent Proportions

On observing successful laboratory flotation machines of the mechanical agitation type we find that when the pulp density is 3 to 1, there is from 30 to 60 grams of ore for every square inch of frothing surface.

Let us see now if the test tube, which was recommended a long while ago, has proportions that are consistent.

Take a test tube of such a diameter that it gives a frothing area of 0.6 sq.in. The quantity of ore required is then, say, 30 grams, and for a 3 to 1 pulp, 90 cc. of water must be added. But the ordinary test tube of this diameter will hold only 85 cc. of water. It is eight inches long. We see then that after making allowances for the volume of ore and air, the test tube would have to be about a foot long.

It is obvious that the adoption of these proportions in such a device would not be consistent. A loaded bubble which chanced to be at the bottom of the tube at the end of the agitation period would have to travel upward a distance of nearly 12 inches against a falling column of solids before it could deliver its burden to the froth. Needless to say, it would be wrecked at the outset and buried beneath the column of ore.

Moreover, the test tube has no facilities for discharging the froth.[2]

The device which is recommended here has been used at the Northwest station of the U. S. Bureau of Mines at Seattle. It consists of two pyrex flasks, one of 250 cc.

and the other of 500 cc. capacity. A rubber nipple is placed on the neck of the smaller one so that when the flaring portion is ground off it will fit snugly into the larger as shown in the photograph.

To prepare a test, the smaller flask is filled with a mixture of ore and water of the desired consistency and emptied into the larger one, after which about three cc. of water is added. After the desired flotation reagents have been added a stopper is placed in the flask and we are ready to proceed with the test.

The procedure of testing is by means of hand agita-

*Published by permission of the Director of the Bureau of Mines.

[1]Del Mar, Algernon, "Differential Flotation of Lead and Zinc Sulphides." *Min. and Sci. Press*, Vol. 117, Nov. 23, 1918, p. 692.

[2]The separatory funnel which has been recommended by "A Special Correspondent," *Min. and Sci. Press*, July 24, 1915, p. 122, and by Ralston, O. C. and Allen, Glenn L., *Min. and Sci. Press*, Jan. 8, 1916, p. 44, is faulty because the proportions are not good and the froth has to stand until the tailing is removed

tion for, say, five minutes. The stopper is removed, the flasks are united, and, after a brief agitation, placed in the position as shown. The extra three cc. of water referred to elevates the lower level of the froth so that it will overflow into a collecting pan when the larger flask is removed. The agitation may be repeated as often as desired by adding a little extra water each time.

The efficiency of course is low as compared with the mechanical devices, but the relative floatability of minerals and relative effects of flotation reagents may be quickly determined.

There are two reasons why the efficiency is low: first, there is no opportunity for the froth to build up during the agitation period; second, a small quantity of gangue lodges on the bench formed by the union of the inner and outer tubes, and by joining the overflow reduces the grade of the concentrate.

The quantity of modifying reagents must be determined by calibrated devices. Otherwise impressions may be misleading. This is demonstrated by the following example.

When four drops of oil was added from a medicine dropper the pyrite floated so freely that the results were adverse. The dropper was then calibrated and it was found that four pounds of oil per ton of ore had been used. The test was then repeated with one drop of oil and the results were encouraging.

This device, then, has three points of advantage over the test tube: It has convenient discharging facilities, and it provides for desirable pulp densities and a consistent area of frothing surface.

Improved Form of Granular Carbon Resistance Furnace for Fusion Point of Coal Ash and Firebrick

By C. H. Lovejoy

A GRANULAR carbon resistance furnace of the type described in Bulletin 129, U. S. Bureau of Mines, "The Fusibility of Coal Ash and the Determination of the Softening Temperature," has been in use for several years at the Pittsburgh Testing Laboratory, Pittsburgh, Pa. In building a new one last summer, several improvements were added, to facilitate operation and the replacement of worn parts. The furnace was built at slight expense from standard fittings, with very little machine shop work necessary.

In the sketch *D*, the base, was made from an old automobile brake drum housing, filled with a mixture, *B*, of broken firebrick and fireclay.

A-A are made in the laboratory from alundum cement, and baked on the hot plate.

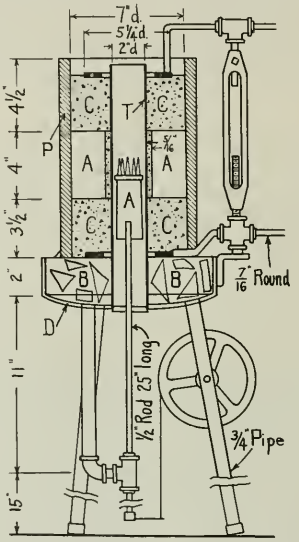
P is a 12-in. length of vitrified clay pipe, with a layer of 20-gage galvanized sheet iron covering the outside.

T, the central tube, is made from 2-in. lengths, $\frac{3}{32}$-in. thick, manufactured by the Norton Co., Worcester, Mass., of No. 288 alundum.

C is granular carbon from the National Carbon Co., Cleveland, O., passing 8 mesh and held on 40 mesh.

The lower wrought iron circular terminal is put in place, the shell *P* set over it, and the lower $3\frac{1}{2}$ in. of carbon poured in. Next the heavy ring, *A*, is placed, the rest of the carbon added, and the top terminal clamped into position. The turnbuckle was intended for bringing the top terminal into close contact with the carbon, but was not found practical, so a set screw was put in the top of the turnbuckle, as shown in the sketch. Of course the terminals are insulated from the iron with hard rubber plugs.

The furnace operates on a 110-volt a.c. line, protected by 100-amp. fuses, and controlled by a 100-amp. 42-point rheostat in series. The furnace is started at about the eighth point, at which the constricted zone should come to a dull red heat in $\frac{1}{2}$ to $\frac{3}{4}$ hr. Now raise the plunger to the top of the furnace by turning the hand wheel, and place on it the alundum pat which carries the Seger cones together with the test cones made from coal ash and dextrine solution. Lower the plunger very, very slowly, giving the dextrine a chance to burn out. Advance the rheostat two points every five minutes until the coal ashes have fused, and estimate the temperature by comparison with the condition of the Seger cones. The plunger may now be raised and the pat with cones removed for closer observation.



Advantages of This Furnace

If this furnace were used for coal ash fusions alone, it would last indefinitely. It is used, however, for fusion points of firebrick up to temperatures of 3000 to 3200 deg. F., at which points the central tube is liable to crack and warp, or the heavy ring, *A*, to fuse. After the furnace has cooled it is a simple matter to remove the rings, beginning at the top, letting the carbon fall through the central tube, and replace the spoiled parts. The carbon in the lower portion lasts indefinitely; that in the constricted zone gradually burns to ash, and should be discarded whenever parts are replaced.

The ease of introducing cones into the furnace and removing for examination, and the possibility of raising or lowering them at any time to the hottest level, has proved to be a great advantage. The increased height of furnace has prevented the iron terminals from becoming too hot, and the solid ring, *A*, stays in place well, yet can be removed when necessary.

Pittsburgh Testing Laboratory.
Pittsburgh, Pa.

Chemical Specifications

By Wallace P. Cohoe

GENERALLY accepted specifications for the purchase of standard chemicals have been and still are lacking, while the development of chemical trade emphasizes the need of them. If sales of sulphuric acid constitute an index of industrial progress, then trade in other chemicals must augment the sign, for even reference to materials by their chemical names shows a certain understanding of what they are. It is also usually an indication of industrial advancement to find that wares are bought on specification. It shows greater information on the part of the buyer, a larger comprehension of his business; while familiarity with specifications by men engaged in trade may be cited as evidence that they know what they are about.

Of course, contracts for chemicals at the present time are made in accordance with definite specifications, but it does not follow, because Brown purchases from Adams 100 tons of 60 deg. pickling acid, and Jones purchases 100 tons of 60 deg. pickling acid from the same Adams, that both buy according to the same specifications. Probably Brown and Jones are using pickling acid for much the same purpose, but their chemists have slight differences of opinion. In this case, Adams, who sells the acid, will be obliged to make two very slight modifications or to supply the same product to each, trusting that he will not be criticised. Both Brown and Jones will probably be satisfied with what they get, but in order to secure any specification whatever the purchasing agent of each must go to the chemist of each and thus two different specifications are born.

This increasing diversity might continue indefinitely were it not for the fact that large consumers, by their great tonnages, actually do fix a type to which the manufacturer is bound to be held in the main. He cannot make a large variety of products without asking a premium for them. If the purchasing agents of various firms had in their possession standard specifications for pickling acid, to still keep to our example, then the problem as regards both the manufacturer and the customer would be simplified. Trade specifications of standard chemicals do exist. Is there any reason why, in most cases, they should not be generally known?

Trade Secrets Legitimate and Here to Stay

Trade secrets are legitimate and there is no use in thinking that specifications will do away with them or that after peace is declared, even though we be destined to live under some new and reformed system of government, we shall know them no more. Trade secrets consist in information that has not become public, and it is not consistent with human nature to reveal that which it is profitable to keep secret. No kind of rule or law can make persons tell everything they know. If anybody doubts this he should visit the library of Cornell University and peruse the torture records which are to be found there.

Trade marks are of value in the case of preparations of secret formula, but in the case of chemicals of known composition the value of a trade mark consists not in putting over something worth a little at a high price upon an unsuspecting or unintelligent buyer, but rather as a mark or guaranty that the goods bearing it shall represent full value.

We are looking forward to big business in chemical industry. There is big business in securities, metals, grain, cotton and all standard merchandise. With the exception of stocks and bonds they are all graded, and daily market quotations giving quantity and price and quality are available. Chemicals are quoted as to value and quantity, but the qualities mentioned in these quotations are vague; they lack the generally recognized standards, such as may be found in regard to cotton, wheat, coffee, etc. We see no immediate need for a Chemical Exchange, but we do see a need for chemical standards. Standardization is necessary before an industry can get into the great brotherhood of trade.

Quality standards are required for a number of purposes. For instance, suppose a shipment of a thousand drums of 76 per cent caustic soda is received and stored. A warehouse receipt is given and a bank lends money on it. Is it electrolytic or made from soda ash, or is it bottoms? The bank does not know, because the warehouse receipt does not tell unless it is accompanied by a satisfactory certificate as to quality. The same holds good as to insurance adjustments. Suppose several carloads of naphthalene are received and made collateral for a loan. Is it prime white, white, or yellow flakes? There may be a difference of 50 per cent in value which the warehouse receipt does not disclose.

An Example for Illustration

Some time ago a firm bought a considerable quantity of potassium permanganate from a dealer. Examination proved that it contained more Glauber's salt than $KMnO_4$. The dealer from whom they bought it set up the claim that he had purchased it in the market and that in point of fact it was potassium permanganate. It was not guaranteed to be free from impurities, nor was there any specification as to what it might or might not contain. The purchasers were left without recourse. Of course, it may be said that it should have been bought on sample and the sample tested. But this need for checking and counter-checking does not make for good trade practices. There is plenty of work for chemists to do in industry besides unnecessary checking up. The word of a responsible manufacturer should be proof of assay when standards are known.

Specifications are also required to make up a correct balance sheet. It is always good policy to be conservative in the valuation of assets, but it is very bad bookkeeping to record assets as something that they are not. It is nothing less than what Wells calls "economic uncleanness" to make incorrect statements even in the interest of conservatism. Judgment may be availed of in affixing prices, but it has no place in listings.

Buyers used to take what they could get. Commercial oil of vitriol was every color from dark brown through various shades of red and pink to nearly water white. It contained arsenic and lead sulphate and iron, but so long as it was 60 or 66 deg. B., the specifications were fulfilled. Now the specifications as to this chemical alone are so diverse and multitudinous that we shall make it later the subject of a special article. The same holds true of nitric and muriatic acids and of soda.

Industry Must Know What It Buys

Chemical industry must know what it buys. Of course, by going to certain manufacturers a buyer can know what he is getting, but factors of location and market often make such a choice impossible. There are many men of many minds engaged in industry and they display vast differences in their several conceptions of trade ethics. The overzealous salesman also is much

better off if he is held to specifications, even though this at first may almost seem to break his spirit. Granted favorable physical and economic conditions, industry will thrive best wherever technical conditions are best known; and the use of and familiarity with specifications is a function of good technology. Establishments that maintain adequate chemical control do know what they buy, but the lack of known standards among sellers makes this task often difficult and it frequently increases costs far beyond what they should be normally.

The problem of standards in the colloidal field is a difficult one, but it is not beyond the range of possibility. We have, for instance, in this country a great variety of clays available for porcelain and pottery and for coating paper. It may be said without fear of contradiction that there is a disposition among American producers to favor the sale of quantity rather than of quality, and that refined and matured clays might be made available if greater efforts were made to prepare them. The fact that chemical analysis has little value in determining their quality has no bearing upon the subject. Specifications may indicate geologic history and treatment in refining and maturing as well as prohibitions as to the presence of undesired bodies. If such specifications were available, many clays now urgently needed might be obtained from domestic sources. This would be good for our ceramic industries as well as for the paper industry. We do know of one large buyer of clay who has succeeded in so standardizing his physical and chemical tests that he is able to write a specification which will represent the qualities desired.

Demands Will Be Met

Dr. B. C. Hesse investigated on behalf of the U. S. Department of Agriculture the dyes which might be allowed in food products. His work involved not only the study of the constitution of the colors themselves and their effects upon the human system, but also a study of the inorganic impurities which may be present in them, of the chemicals that entered into their manufacture and the possibility of traces of arsenic, copper, lead, etc. This might be called a work of super-refinement or meticulous caution, but it is typical of the scholarship that will insist on having its demands met, either by American or foreign manufacturers.

I have in preparation a book on chemical specifications to be published by the McGraw-Hill Book Co. The task of getting together the material which is now well under way has presented some difficulties, although in the main my inquiries have met with generous responses from manufacturers.

Examples of Trade Specifications

In order to illustrate what I mean, I add a few examples of existing trade specifications, concerned with chemicals mostly below the first rank in importance. These are given as in actual use by reputable firms. They are given also in the hope that they may if possible promote discussion and receive comment to the end that greater enlightenment on the subject may prevail.

Acetic Anhydride:

Commercial form: Colorless liquid.
Boiling point 130 deg. to 140 deg. C.
Contains not less than 60 per cent acetic anhydride and not more than 40 per cent glacial acetic acid.
Contains not more than 0.1 per cent chlorine.
Contains not more than 0.1 per cent sulphur.
Delivered in carboys.

Commercial Acetone:

Colorless liquid.
Consists chiefly of acetone, methyl alcohol and methyl acetate derived from crude wood alcohol.
Contains not less than 55 per cent of true acetone by the Messinger test.
Delivered in steel drums.

Commercial Tannic Acid:

Commercial powder, yellow to brown in color.
Average commercial purity of 80 to 88 per cent.
Clearly soluble in water and 20 per cent acetic acid.
Moisture 12 per cent.
Ash 2 per cent.
Put up in barrels of 350 lb. net.

Ammonium Chloride:

White crystalline solid.
Average commercial purity 99 per cent.
Packed in form of powder, which must be free from grit or other foreign substance.
Must be white or nearly white in color.
Must contain at least 98.1 per cent ammonium chloride on dry basis.
Must not contain more than 1 per cent known volatile impurities.
Moisture, not more than 0.25 per cent.
Pyridine, not more than 0.005 per cent.
Thiocyanates, not more than 0.01 per cent.
Must contain no trace of acidity or of phenols.
Packed 250 lb. to a barrel 19⅝ x 30 in. with crêpe paper lining.

Carbon Tetrachloride:

Colorless liquid.
Boiling point, 75 to 76 deg. C.
Sp.gr. 1.596 at 15 deg. C.
Average commercial purity, 98.5 per cent.
Allowable impurity not more than 2 per cent. of CS_2.
Packed in 55 or 110 gal. drums.
Extra for packing and shipping in carboys or bottles.

Naphthalene:

White crystalline solid.
Melting point, 79 to 80 deg. C.
Boiling point, 218 deg. C.
Should boil off within 1 deg.
Should be white and volatilize without residue.
Must not become dark colored when agitated with concentrated sulphuric acid.
Should not contain phenols or quinoline bases.
Crystals should be dry and rattling without adhering oils.
Packed in ordinary barrels containing 200 lb. with brown paper lining.

Potassium Permanganate Commercial:

Commercial crystal.
Color, bronze to steel blue.
Commercial purity average 96 to 99 per cent $KMnO_4$.
Allowable impurities are small amounts of KCl and MnO_2 derived from the process of manufacture.
Unallowable impurities—sulphates.
Packed in cans or drums in accordance with the I.C.C. regulations regarding oxidizing materials.

Sodium Cyanide:

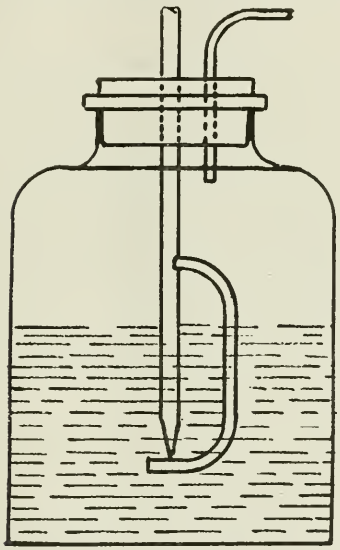
Commercial 96 to 98 per cent pure white crystalline lumps.
Melting point 560 deg. C.
Boiling point above 800 deg. C.
Sp.gr. 1.53.
Should contain 96 to 98 per cent NaCN.
Impurities 2 to 4 per cent.
Allowable impurities—carbonates, hydrates or cyanates.
Unallowable impurities—chlorides and sulphides.
Packed in tin lined boxes or sheet iron drums, hermetically sealed.

Sale of Picric Acid Plant

Bids on the Government picric acid plant at Brunswick, Ga., will be opened May 20. The plant consists of a 2000-acre tract on which are located all the buildings necessary for its operation. Prospective bidders will be given all the facilities for inspecting the property by applying to the Cincinnati District Salvage Board, Cincinnati, Ohio.

Synopsis of Recent Chemical and Metallurgical Literature

Determination of SO_2 in Gases.—In the determination of sulphur dioxide by the iodine method, the chief error encountered is the tendency to rush the gas through the iodine solution too quickly for the interaction between the SO_2 and iodine to be complete, with consequent erroneous results. To overcome this difficulty MR. O. D. BURKE (*Chemical News and Journal of Physical Science*, Dec. 6, 1918) used the following apparatus: A narrow glass tube is drawn out at one end into a very fine capillary, which is ground level at the point or end. Another glass



APPARATUS FOR DETERMINATION OF SO_2 IN GASES

limb is fused on to the straight limb and extends downward to just beneath the capillary, where it is flattened out and the top surface ground. The capillary is made to fit tight on the flat ground surface of the second limb. In this way the gas passing through the capillary tube is broken up into very fine bubbles no larger than a pin point; also the space is so restricted for the passage of the gas that no rushing through can take place, and the time interval for the passage of a certain volume of gas is identical in all cases, thereby with just ordinary care insuring extreme accuracy. This apparatus will prove a valuable addition to laboratories where SO_2 and many other gases are to be determined accurately.

Oxygen as a Revolutionizer of Industry.—The recent extraordinary progress in the industry of nitrates, based on the fixation of atmospheric nitrogen, is accompanied by the production of cheap oxygen as a by-product. In a paper read before the Société de l'Industrie Minérale, M. F. LAURE outlines the importance of the part this cheap oxygen will be called upon to play in the development of industry (*Bulletin et Comptes Rendus* de le Société de l'Industrie Minérale, 3éme livraison, 1918).

Besides the existing industries using oxygen, such as autogenous welding, manufacture of precious stones, metal cutting, medicines, etc., the following new uses are in view. Gas lighting will be revolutionized, as a Welsbach lamp using illuminating gas admixed with oxygen will give a light intensity of more than ten times that obtained when using only illuminating gas. Hence new forms of burners and economy of fuel will result. In metallurgy oxygen admixed to the air blown into the furnace will increase considerably the temperature and the efficiency of fuel, and also permit the use of cheaper qualities of fuel. Calcium carbide will be produced in blast-furnaces by purely thermic methods. Alumina will be reduced by carbon. Auriferous quartz will be melted. The glass industry will be revolutionized by the easy fusing of all forms of quartz. The thermal efficiency of the use of coal will be so improved that a new chemistry intermediary between the old chemistry and the chemistry of the electric furnace will be created. The manufacture of sulphuric acid will be much accelerated by a powerful oxidation of sulphurous acid. The cheap production of ozone, or electrified oxygen, will enable its greater use, notably for the sterilization of drinking water and the maintenance of a practically constant purified atmosphere in homes, public places, factories, mines, etc.

Scarcity of Raw Materials in Germany.—How hard it is on the German industry to keep up with the conditions of having the raw materials supply cut off is shown by the following few examples: For copper, they use a cupriferous schist of 0.7 to 1 per cent copper, instead of the previous 2.5 per cent. For lead, a variegated sandstone containing some lead carbonate, which before has been considered useless, is now worked, although it entails a loss of 40 to 50 per cent in lead. For aluminium they use a poor quality of bauxite and even clay. Wolfram is now obtained from wolframite with 0.06 per cent instead of the former 1 per cent wolfram. Vanadium is recuperated from slags with 0.7 per cent vanadium. Their present supply of chrome is a chrome ore of 24 per cent Cr_2O_3 instead of the former 48 per cent ore. Nickel and cobalt are obtained from waters pumped out of mines in which they are dissolved. For sulphur they use a 41 per cent pyrite instead of the former 52 per cent, also gypsum and anhydrite. They work phosphates with as low as 20 per cent content instead of the former 80 per cent (*Métaux, Alliages et Machines*, Mai, 1918). There is no doubt that the metallurgical improvements required under such conditions will be ultimately of a general benefit to the efficient use of the present mineral wealth.

Recent Progress in the French Chemical Industries.—Besides the progress realized during the last few years in the pre-war existing industries, special attention has been given to the manufacture of products heretofore imported from Germany. Among these the most important are: The production of magnesium, asbestos and rubber jointing materials, permanganate of potassium, pentasulphide of antimony, sulphide of sodium, which has replaced the sulphide of arsenic in tanneries; polishing powders for metals,

glass, aluminium, bleaching liquids (extracts of javel), calcium carbide, etc. The production of sulphuric acid has increased from about 850,000 tons per year in pre-war times to about 2,000,000 tons per year, and 3000 tons per year of oleum, and is still on the increase. The manufacture of nitric acid has increased from about 12,000 tons per month to about 50,000 tons per month. The production of hydrochloric acid has grown to such an extent that there is now available a great surplus, and the liquid chlorine industry, which was nil before the war, is now capable of manufacturing about 15,000 tons per year (*Génie Civil*, Nov. 9, 1918).

Water-Power Resources in Norway.—The following is an abstract of a paper published in the *U. S. Commerce Reports* of March 13, 1919. The power available for development in Norway is estimated at about 15,000,000 hp. The utilization of this water power on a large scale started about 15 years ago, and by this time it is estimated that 1,300,000 is used. The State has bought a great number of waterfalls in all parts of the country, with the intention of electrifying the State's railways. Of the 1,300,000 hp. already developed, 1,100,000 is in private ownership and 200,000 belongs to different communities.

The main Norwegian industries depending upon hydro-electric power are: The saltpeter industry, mostly in the Telemarken district of Southern Norway. More than 300,000 hp. is used for making nitric acid, Norwegian saltpeter and other nitrates and nitrites. The manufacture of calcium carbide is the oldest electrochemical industry of the country, and the production is growing yearly, necessitating the construction of several plants at different places. The present yearly production is about 100,000 tons. The American company has a concession to use 84,000 hp. in the district of Stavanger, and a large plant for utilizing this power is now being built. The several ferrosilicon plants produce about 30,000 tons per year, and the production of ferro-alloys, aluminium, zinc and similar products is continuously increasing. Norway possesses more water power in proportion to its population than probably any other country. The developed horsepower per capita is larger than in any other country—more than 0.5 hp. for every person in the country.

Treatment of Waste Liquors From Paper Pulp Mills.—The solution of the problem of converting factory waste into valuable by-products has enabled more than one industry to prosper in the face of severe competition. While conditions have not reached this point in the paper industry, the problem is nevertheless an important one because of the enormous tonnage of waste.

As has been the case in other industries, the first steps were taken, not with a view to the recovery of valuable material, but because of legal difficulties arising from older practices[1]. Thus in England prior to 1876, the waste liquor was allowed to flow into the streams. The introduction of the rivers pollution act compelled the paper manufacturers to adopt other methods for the disposal of their waste. It was soon found that, by evaporating the liquors to dryness and calcining the residue, from 90 to 95 per cent of the alkali used could be recovered in the form of carbonate. While this treatment was satisfactory in that it conformed with the law and at the same time permitted the recovery of alkali, it was inefficient from the standpoint of by-product recovery, as only the inorganic material was reclaimed. It has been pointed out[2] that, for every ton of dry pulp made, a ton of organic matter is discharged with the waste. As soda and sulphite pulp production in 1914 was 1,500,000 tons[3], the value of utilizing the organic material is self-evident.

During the last few years, several developments have been made along this line. Alcohol has been produced by fermenting the carbohydrates in neutralized sulphite liquor.[4] In Sweden, the lignin is precipitated and used as fuel.[5] The neutralized liquor has also been evaporated and used as a binder for roads, briquettes and as a tanning material, under the name of glutrin[6].

Recently, a number of patents have been granted which are assigned to the West Virginia Pulp & Paper Co.[7] and which indicate some of the possibilities of research in this field.

Black liquor from the caustic soda process of producing pulp is concentrated in multiple effect evaporators until the water content is about 50 per cent and the sp.gr. 1.32. In some cases, as when working with sulphite liquors, it may prove advantageous to add a small amount of caustic soda during the concentration process. About 50 per cent of quicklime is now added to the liquor in a rotary mixer. The slaking of the lime evolves sufficient heat to convert a portion of the water into steam, which in escaping renders the mass porous. Also the sodium compounds are causticized.

This porous causticized calcareous ligneous acetate material, which is termed calignate, weighs only 38 to 40 lb. per cu.ft., whereas the true specific gravity of the material is 1.9. Its strength under compression is from 612 to 987 lb. per sq.in., and the material will retain its form up to 500 deg. C.

Distillation of calignate in a revolving retort at 600 to 700 deg. C. in the presence of superheated steam yields acetone[8], along with other ketones, heavier oils, ammonia and fixed gases which may be used as fuel. When calignate is made with black liquor from poplar wood, yields of acetone and methyl alcohol up to 5 to 10 per cent of the weight of organic material present have been obtained. Leaching the residue with water recovers the sodium hydroxide, while heating in a rotary kiln converts the final residue into quicklime.

Calignate is heated to 250 deg. C. in a closed retort so that methyl alcohol, moisture, etc., are driven off, without, however, decomposing acetates present. The mass is cooled in the absence of air, extracted with hot water, and the resulting solution concentrated to 30 to 32 deg. B. Carbon dioxide is passed into the solution and the $NaHCO_3$ which crystallizes out is filtered off. The solids in solution now contain sodium acetate, 50 per cent; sodium and potassium salts of lactonic acids, 25 per cent; black coloring matter, 10 per cent; $NaHCO_3$, 5 per cent; NaCl, 10 per cent. The sodium acetate amounts to 10 to 12 per cent of the weight of the calignate. After neutralizing the solution with acetic acid, the coloring matter is precipitated with lime and the sodium acetate recovered by evaporation and crystallization. The sodium acetate in the mother liquor is

[1] Cf. Cottrell Process; CHEM. & MET. ENG., XX, p. 103.

[2] CHEM. & MET. ENG., XIX, p. 213.
[3] Abstract of the Census of Manufactures, 1914, p. 156.
[4] CHEM. & MET. ENG., XVIII, p. 360; see also XIX, p. 97.
[5] CHEM. & MET. ENG., XIX, p. 213.
[6] CHEM. & MET. ENG., XIX, p. 568.
[7] U. S. Pat. 1,298,476-1,298,481 incl.; 1,298,594; Mar. 25, 1919.
[8] Cf. CHEM. & MET. ENG., XX, 190.

decomposed with an equivalent amount of H_2SO_4, the Na_2SO_4 crystallized out and the acetic acid distilled off.

The lactonic acids may now be recovered either as their alkali salts or as the free acids.

When waste sulphite liquor is digested for several hours with 2 to 6 per cent of caustic alkali in a rotary digester under 80 to 100 lb. pressure, the woody material is converted into lignin and some of the sugars present are apparently transformed into lactonic acids which give acetone and other ketones and alcohols on distillation.

The precipitation of the lignin in a form which can be easily filtered is facilitated by passing in carbon dioxide. The lignin represents about 30 per cent of the dry weight of the organic matter in the original liquor and may be used as a tanning material or as an inert filler for paint, linoleum and other products. The filtrate may be converted into calignate by the method outlined above.

Specifications for Leather Belting.—In view of the quantity of leather belting used in the industries for the transmission of power, it seems remarkable that practically no specifications exist which are applicable to modern practice. That such is the case, however, is pointed out by HARRY A. HEY in *Industrial Management* for April, 1919, and he endeavors to supply the deficiency by outlining a set of specifications which has been in satisfactory operation for the purchase of a large amount of belting during the past three years.

In drawing up these specifications, due consideration has been given the fact that the raw material itself is of a variable nature and that, during manufacture, the human element is introduced to a greater extent than in many industries. Furthermore, the requirements should cover the best commercial practice and no more, lest they defeat themselves through the inability of manufacturers to live up to them.

1. These specifications are intended to cover first-quality, center-stock, oak-tanned leather belting for general use. Previous specifications are hereby cancelled.

2. The material and workmanship must be guaranteed by the vendor to be of the highest quality and the finished product equal in strength, pliability, durability and performance in use to any obtainable.

3. The purchaser reserves the right to subject each roll of belting when received to the following tests. Failure to pass any of them will be cause for the return of the entire roll for full credit, plus carrying charges both ways. The manufacturer's name and brand must be stamped on all belts every ten feet and the length every foot.

4. When unrolled freely on a flat surface, without tension, the belt must lie flat at all points and be full length as marked. There must be no evidence of injurious surface blemishes, artificial finish to produce high polish, shimming or excessive leveling, cracking when bent grain side out through 180 deg. over a $\frac{1}{2}$-in. diameter rod for single belts and a 1-in. rod for double belts, or piping when similarly treated grain side in.

5. No section shall be longer than 54 in. or shorter than 42 in., including laps, except in double belting, where shorter pieces may be used provided they do not exceed 10 per cent of the total number of laps.

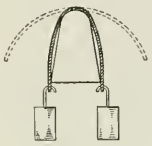
6. (*a*) Thickness must not vary more than $\frac{1}{32}$ in. (*b*) Width must be within $\frac{1}{32}$ in. of nominal size.

7. Character of leather must be uniform throughout the entire length of the belt.

8. One or more test pieces 1 in. wide will be cut at random lengthwise of the belt. Each test piece must show a tensile strength in pounds per inch of width not less than the following table. The vendor may furnish any thickness or weight of belting which will meet this requirement. Total elongation at the required load must not be less than 15 per cent or more than 20 per cent in 2 inches:

	Single			Double		
	Under 2 Inches	2 to 4 Inches	Over 4 Inches	Under 4 Inches	4 to 8 Inches	Over 8 Inches
Light	580	605	630	900	1000	1100
Medium	630	675	720	1100	1200	1300
Heavy	720	765	810	1300	1400	1500
Extra heavy	810	900	990	....	....	....

9. Cemented joints must not crack or yield before reaching a load equivalent to 90 per cent of the tensile strength specified in paragraph 8.



PLIABILITY TEST

10. A section 40 in. long and the full width of the belt will be tested for pliability by being suspended over a form of the dimensions shown, grain side down, and weighted at each end. Both ends must touch the bottom corners at a total weight per inch of width within the following limits:

	Minimum, Ounces	Maximum, Ounces
Light, single	8	15
Heavy, single	10	20
Light, double	45	60
Heavy, double	60	80

11. The total lubricating matter shall be increased by oil dressing to approximately 12 to 15 per cent by weight when examined in accordance with the practice of the American Leather Chemists' Association. Chemical examination shall not show loading for artificial weight, free mineral acid or anything detrimental to the strength, pliability or durability of the belt.

12. Belting must not run unevenly on the pulleys, show excessive stretch or develop other defects of material or workmanship in service, when properly applied.

For a complete discussion of the points covered by these specifications, reference should be made to the original article, but the following notes may call attention to the more important points. The numbers refer to the individual specifications.

Strength.—Center stock is the area of a prime steer hide extending from 15 to 18 in. on either side of the backbone and from the root of the tail about 48 in. toward the shoulder. Strength should be expressed in pounds per inch of width, instead of pounds per square inch (1, 5 and 8).

Pliability.—A stiff belt may be so badly burned by excessive slip when new as to shorten its life considerably. In order to transmit a given load, a stiff belt has to be tightened more than a pliable one, with the result that the increased bearing pressure consumes more power (10).

Artificial Finish.—For the sake of appearance, many manufacturers give their belts a high gloss finish which has a low coefficient of friction. Such a belt is liable to slip when new and become burnt in the process. For the same reason, manufacturers do not send out their product oil dressed unless so requested, although the dressing increases the life of the belt, as well as its resistance to moisture, fumes, mineral oil and other destructive agents (4 and 11).

Recent Chemical and Metallurgical Patents

Leaching Kiln Dust.—EVALD ANDERSON, of Los Angeles, Cal., finds that if a cement kiln is fired with pulverized coal, the ash-forming substances tend to combine with the volatilizing alkaline oxides, forming a compound which is slowly soluble in water. He therefore proposes to treat the resulting dust in a digester with water at high temperature and pressure, finding that in many cases it will raise the potash extraction up to 90 per cent within one hour's time. Lime, either from the kiln dust, or as an added reagent, is also thought to aid the solution of the valuable potash. (1,298,154; assigned to International Precipitation Co., March 25, 1919.)

Silver From Manganese Ores.—MARTINUS H. CARON, of Weltevreden, Java, patents an improvement of his former process covered in No. 1,232,216. In silver and gold ores bearing considerable quantities of MnO_2, it is well known that cyanide or amalgamation processes yield very poor extraction, possibly because of a compound between gold, silver and manganese. Caron proposes to break up these compounds, forming MnO and metallic silver or gold by a reducing roast at some temperature up to 1000 deg. C. which experience with that particular ore indicates, and then preventing reoxidation and recombination by cooling the calcine in producer gas or otherwise out of contact with oxygen. Thereafter cyaniding or amalgamation in the ordinary way will give good extractions. (1,298,454; assigned to Research Corporation of New York, March 25, 1919.)

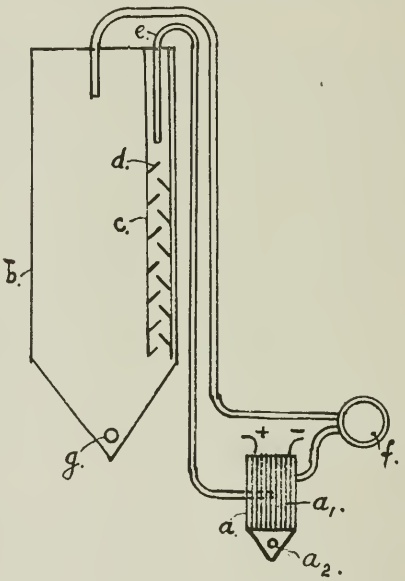
Steel Heat Treatment.—FEDERICO GIOLITTI, of Turin, Italy, patents an improvement in heating practice prior to quenching steel articles, in which he specifies that the metal be held at a point near that where diffusion of the constituents takes place with the greatest rapidity (i.e., at least 100 deg. C. above Ac_3) for a time depending upon the mass and shape of the piece. He then cools the furnace slowly to at least 30 deg. C. below the temperature necessary for effecting the ordinary homogeneous hardening (i.e., at least 50 deg. C. above Ar_3), holding the temperature constant for a somewhat shorter time, and then quenching the metal in a suitable medium. Following this, any correct tempering or annealing practice may be utilized to modify the resulting physical properties. Several practical examples are cited from experiments conducted to determine the best time and temperature limits. (1,296,649; assigned to Giov. Ansaldo & Co., Genoa, Italy, March 11, 1919.)

Metal Dust.—M. H. NEWELL, of San Francisco, Cal., proposes to make zinc dust by vaporizing spelter in a retort and condensing the vapor direct to solid without passing through the liquid phase. He notes, however, that if vapors come into contact with hot condenser walls, droplets of liquid metal form, which introduce large particles into the otherwise finely divided fume, and he proposes to prevent this contamination by a large cylindrical metallic condenser, connected to the retort mouth with a connecting hood, which may or may not be heat insulated. (1,295,573; assigned to The Alloys Co., Feb. 25, 1919.)

Australian Patents

Ore Flotation.—To preferentially separate lead sulphide (galena) from mixed sulphide ores by agitation, aëration froth flotation, a ferric salt such as ferric chloride or sulphate or sodium or potassium ferricyanide is added to the circuit water, preferably in the proportion of 5 lb. per ton of ore treated. (Australian Patent, No. 5714—1918. BROKEN HILL SOUTH SILVER MINING CO., T. A. Read, assignee.)

Recovering Gold and Silver.—To directly precipitate gold and silver from pulped ore without filtering, the pulp is agitated in a cyanide vat *b* by an air jet *g* and is drawn off to an electrolytic vat through a compartment *c* which is provided with perforated baffle plates *d* to separate the coarser particles. A syphon *e* conveys the pulp to an open precipitating vessel *a* having an air inlet pipe a_2 to maintain the



ore in suspension, and provided with depending electrodes a_1, through which low-tension current is passed. A pump *f* returns the pulp to the cyaniding vessel. The anodes are of iron containing 30 to 40 per cent silicon, and the cathodes consist of lead coated iron or mild steel plates, which are about 1 in. apart. (A. A. LOCKWOOD, Australian Patent No. 7097—1918.)

Treatment of Zinkiferous Ores.—To facilitate the formation of a pure zinc sulphate solution, the zinc is volatilized and dissolved in sulphuric acid. Impurities such as arsenic, antimony and cadmium are precipitated by barium sulphide, or calcium sulphide which is thrown down as insoluble sulphate. The ore is crushed, roasted, damped and mixed with carbon, and is fed to a furnace provided with a perforated grate to admit an air blast. The zinc, lead and other volatile constituents are here volatilized, and the resulting fumes collected in a baghouse. The residue is smelted, and any remaining lead and zinc are volatilized and collected in the main baghouse, the

non-volatile metal being recovered in a matte. The fume dust is now treated with sulphuric acid, lead sulphate settling to the bottom and the clear liquor being decanted and treated with barium sulphide. The zinc is finally deposited by electrolysis and sulphuric acid liberated, and used again. Zinc plates are used as cathodes, and gum arabic is added to insure an even deposition of zinc. (Australian Patent No. 6456—1918. J. H. and P. McP. GILLIES. Feb. 5, 1919.)

Sulphur From Roaster Gases.—ARTHUR B. FOSTER, of Washington, D. C., has discovered that if SO_2 gases from a mechanical roaster, working on ordinary sulphide ores, be passed through a granular mass of sulphides heated to from 750 to 900 deg. C., elemental sulphur is slowly produced, perhaps after the following equation:

$$2SO_2 + 3FeS = 5S + Fe_3O_4$$

If steam be added to the roaster gases, the hot sulphides may decompose it thus:

$$4H_2O + 3FeS = Fe_3O_4 + 3H_2S + H_2$$

Hydrogen sulphide then actively decomposes SO_2 by the well known reaction:

$$SO_2 + 2H_2S = 2H_2O + 3S$$

The inventor finds that if the granular ore be placed in a vertical retort, and the lower portion heated to a point just below sintering, moist roaster gases will rapidly and almost completely be broken up. Cold gas and sulphur fume will then be drawn from the top, and sent to a Feld washer or other suitable appliance for collecting the sulphur. Hot ore from the retort, partially desulphurized, forms the feed for the mechanical roaster. (1,296,585; assigned to Sulphur Syndicate, Ltd., of London, Eng., March 4, 1919.)

Personal

The American Red Cross asks our assistance in locating LIEUT. WILLIAM H. STUART, son of Duncan C. Stuart, of 12 Maple St., Oneonta, N. Y., and will appreciate any information that can be secured relative to his whereabouts. Lieut. Stuart is 27 years of age. He arrived from overseas service on Jan. 13 and went to Washington, where he was given his discharge. He returned to New York, and was last seen in that city Jan. 18 at 7:30 p.m. He is a graduate of Colgate, class of 1914, and took two years' post-graduate work at Brooklyn Polytechnic Institute. He is 5 ft. 8 in. tall, has dark hair and blue eyes and a ruddy complexion. He has a brown mole on the left side of his nose. He has three gold service chevrons on his sleeve, if in uniform. He was wearing, when last seen, spiral puttees and not the customary leather ones for officers. Information relative to him may be sent to D. C. Stuart, 12 Maple St., Oneonta, N. Y.

MR. J. P. BONARDI, assistant chemist, U. S. Bureau of Mines, who has been at the Seattle station experimenting on flotation problems with W. H. Coghill, has returned to his assignment at the Golden, Colo., station.

DR. JAMES E. CAMPBELL, president of the Dexter Sulphite Pulp & Paper Co., Dexter, N. Y., has returned from Europe, where he spent three months on a semi-official visit for the United States Government investigating the chemical, mechanical and labor conditions in the paper and pulp industry in France, England, Norway and Sweden.

MR. GORDON L. CAVE, formerly on an editorial detail with the pyrotechnic section, research division, Chemical Warfare Service, has accepted a similar position with the research department, Brown Co., Berlin, N. H.

MR. VERDON O. CUTTS, Sheffield, England, is visiting electrometallurgical centers in the Eastern and Central States.

MR. HERBERT FLECK has been appointed chief chemist, Crucible Steel Co., Pittsburgh, Pa., succeeding his brother, Mr. E. M. Fleck.

DR. WILLIAM MCPHERSON, who was recently discharged from the Chemical Warfare Service of the U. S. A., has returned to his former position at the Ohio State University, Columbus, Ohio.

MR. A. H. RICHARDS has been made superintendent of the copper smelter at Garfield, Utah. Before becoming assistant superintendent at Garfield for several years he held a like position at the A. S. & R. lead smelter at Murray, Utah.

MR. H. M. ST. JOHN has resigned his position as research engineer for the Commonwealth Edison Co. of Chicago to become assistant manager for the Detroit Electric Furnace Co.

MR. JOHN THOMPSON, chief engineer of the H. Koppers Co., will be in Europe for several weeks on a professional visit at various points in the Allied countries.

MR. FRANK J. TONE, past president of the American Electrochemical Society, has been made president of the Carborundum Co., Niagara Falls, succeeding the late Mr. Frank W. Haskell. MR. GEORGE R. RAYNER succeeds R. B. MELLON as vice-president and MR. F. H. MANLEY retains the office of treasurer.

MR. WALTER HARVEY WEED is consulting engineer for the Crystal Copper Co., which is operating the Goldsmith mine at Walkerville, Mont.

The following officers of the New York Section of the A. I. M. E. were elected May 7: E. P. MATHEWSON, chairman; R. M. ATWATER, JR., and WILLIAM YOUNG WESTERVELT, vice-chairmen; WILBER JUDSON, treasurer; E. S. BERRY and L. W. MAYER, executive committeemen.

At the annual meeting of the Chemists' Club held at Rumford Hall Wednesday, May 7, the following officers were elected: President, ELLWOOD HENDRICK; resident vice-president, WILLIAM F. HOFFMAN; non-resident vice-president, VICTOR F. BLOEDE, of Baltimore; secretary, J. R. MACPHERSON KLOTZ; treasurer, HENRY M. TOCH; trustees to serve three years, EDWARD WESTON and ALLEN ROGERS.

Current Market Reports

The Non-Ferrous Metal Market

Saturday, May 10.

Aluminium:—The open market is nominal at 33c. Sheets 18 gage and heavier, 42c. Powder, 0.70-1.40 lb.

Copper:—The market continues to be quit with 15¾c. being the uniform price.

Copper sheets, hot-rolled	lb.	$0.22½—	.....
Copper sheets, cold rolled	lb.	.23½—	.....
Copper bottoms	lb.	.23½—	.....
Copper rods	lb.	.19½—	.....
Copper wire	lb.	.17½—	$0.18
High brass wire and sheets	lb.	.18½—	.....
High brass rods	lb.	.17½—	.....
Low brass wire and sheets	lb.	.18½—	.....
Low brass rods	lb.	.21½—	.....
Brazed brass tubing	lb.	.29½—	.....
Brazed bronze tubing	lb.	.33½—	.....
Seamless copper tubing	lb.	.28 —	.....
Seamless bronze tubing	lb.	.29½—	.....
Seamless brass tubing	lb.	.30 —	.....
Bronze (gold) powder	lb.	1.00 —	.....

Antimony:—No spot antimony is now available at 7c., though prompt shipments from the Orient can be obtained at this price.

Lead:—Market is inactive. East St. Louis quotes 4⅜c. and New York 4.5 to 5c. Sheet lead, 7⅜c.

Tin:—The price of 72½c. continues; however, when the price does change, it will be because the allotment has been consumed, and no previous notice is likely to be obtainable.

Zinc:—Spelter has gone down as low as 5.95c. during the past fortnight, and is now quoted at 6c. at East St. Louis. New York, 6.45c. Zinc dust, 9c. Sheets, 11c.

OTHER METALS

Bismuth	lb.	$3.20 — $3.65
Cadmium	lb.	1.40 — .....
Cobalt	lb.	2.50 — 3.50
Magnesium	lb.	1.75 — 2.10
Mercury	75 lb.	80.00 — .....
Nickel	lb.	.40 — .45
Tungsten	lb.	Nominal
Iridium	oz.	175.00 — .....
Palladium	oz.	120.00 — 121.00
Platinum	oz.	99.00 — 100.00
Silver	oz.	1.05½— .....

The Iron and Steel Market

The basic situation in the iron and steel market has not changed, but the atmosphere has been somewhat cleared by the final exit from the stage of the Industrial Board at Washington. The board had got into a hopeless tangle in its "controversy" with the Railroad Administration, desiring the latter to endorse prices for steel which the railroads considered too high, and to participate in a price maintenance movement which the Attorney General had declared in a formal opinion he considered illegal, a fact which the Industrial Board did not divulge, and only came out in a statement by its ex-chairman after he had resigned.

The resignation of the Industrial Board destroys any connection it may have been thought existed between Washington and the maintenance of steel prices. Nothing has occurred in the steel market as a result of the disappearance of the board. Now, as formerly, steel prices rest upon the general understanding of the steel producers individually that it is for their best interest to maintain existing prices, reduced from war-time prices as they have been by about $4 a net ton in December and $7 a net ton in March.

Steel Prices

If steel prices advance it will be because of a general buying movement starting on the present level. Never in the course of steel market history has a general buying movement, with advancing prices, started except after a break to abnormally low levels. Buyers have confidence in the market only when it is advancing. In all the market dips that have occurred little steel has been sold at the low point.

If steel prices decline it will be the result either of an accident, through one or more producers departing from the present understanding, or through the leaders in the trade reaching a judgment that the time has become ripe for starting a movement. The producers do not hesitate to cut prices if they feel certain that thereby they can set the market in motion. If they maintain present prices longer than necessary it will be through incorrect judgment due to their being less sanguine as to the future of business than they should be. If they allow the market to break before buyers are ready to take hold in a large way they will lose money through producing steel at less than cost, including overhead, when by maintaining prices they would have been able to make their overhead.

Operations

In April, according to the monthly report of the American Iron and Steel Institute, 2,239,711 gross tons of steel ingots were produced by 30 companies which in 1918 made 84.03 per cent of the country's entire output. From this it may be computed that the industry made steel in April at the rate of about 31,900,000 tons per annum, which was 65 per cent of capacity, taking capacity at 49,000,000 tons a year. This compares with 77 per cent in March, 85 per cent in February and 87 per cent in January. At the same rate of progression the operating capacity at the middle of May would be 53 per cent, while current trade estimates would place the rate at about 55 per cent.

There is a wide divergence in operating rates. The Steel Corporation is operating at a heavier rate than the independents as a whole, and in some cases it is doing so by operating some plants almost in full, with others entirely idle. In some branches, as the sheet and tin plate branches, the corporation is distributing work uniformly at each plant. Among the large independents the rate of operation is more commonly 40 or 45 per cent than a higher rate, while a few small interests are operating almost full, others being entirely idle. This divergence in operating rates makes price maintenance less easy than it was in 1908, when all producers operated at substantially the same rate.

Some Improvement

There has been improvement in the steel market in some respects, but increases in the volume of new bookings are usually more than offset by the exhaustion of old orders. Only two classes of consumers show full normal demand, these two being the automobile trade and the petroleum industry.

An important factor in the situation is the fact that steel making capacity has increased 40 per cent since 1914 and 100 per cent since 1907. On the one hand it would appear that a very large demand for steel would be necessary in order to give the industry a full operation at this time. On the other hand it is clear that if the greatly enlarged industry can operate even at 55 per cent when there appears to be scarcely any demand it would be no remarkable thing for a turn in affairs to bring about demand for the fullest output possible.

While the steel producers have such objections to an open market for their product that they can adhere to the existing schedule without any formal agreement to that effect, the merchant furnaces declared long ago that they regarded their market as an open one, and individual furnace interests frankly declare their willingness to cut prices if attractive orders are to be secured. Inquiries have been so small individually, however, that there has been but little price cutting. The furnaces do not specifically desire lower prices, but they desire information. They would like the market to show where it desires to go, and as promptly as possible, whereupon the furnaces individually can decide whether or not to blow out and await either lower costs or higher prices. Many have already done so. With relatively few exceptions the pig iron prices effective March 21 still obtain, while in steel the March 21 schedule is in full force, and well maintained.

The Chemical Market

New York, May 10.

Coal-Tar Products:—There has not been a great deal of change in this situation during the interim. The crudes continue to be moving in large quantities, and the situation in general is somewhat more encouraging than it was a few months ago. Benzol is moving in large volume, with contracts for quantities being closed right along. The other crudes also appear to be on a more stable basis, and the price situation, while unchanged in general, is firmer. It is not unlikely that higher prices will prevail when the large stocks held by the Government are disposed of. The intermediates, however, are sluggish and weak, with consumers confining their purchases to immediate requirements.

Benzol:—An unusually heavy volume of business is passing in this market. Several of the smaller plants are not operating, and while material is not scarce, it is not being offered as liberally as formerly. Prices are firm, though unchanged. Spot material is available only in limited quantities.

Phenol:—Some large sales have been closed of late, and though material is plentiful, the elimination of stray lots in the hands of weak holders has stimulated the market somewhat and prices are slightly higher.

Naphthalene:—While there is an improvement in the demand for spot and nearby material, there are but few large contracts being closed. Material is plentiful and prices are unchanged though slightly firmer.

Toluol:—There is a fair demand for moderate quantities of drum material, although there is but little business passing in tank-car lots. Buyers in most instances are closing only for current requirements. Prices are slightly firmer due to curtailment in production.

Cresol:—A steady volume of business is passing through regular channels, but there is no unusual activity. Prices are unchanged, and if anything are slightly easier.

Metol:—The domestic production of this material is now perfected to the state where a regular supply is possible.

There are moderate quantities of the foreign grade available, but prices are so much higher than those for domestic goods that the domestic is favored.

Alpha Naphthol:—There is an improvement in the volume of business passing, but there are large quantities of material available and prices are barely steady.

Aniline Oil:—The volume of business passing is not at all heavy; there is plenty of material available and prices are slightly easier.

Dimethylaniline:—The demand is confined to moderate and small quantities. The supply is ample with prices unchanged.

Diethylaniline:—Small quantities are passing hands, but the demand is not brisk and prices are unchanged.

Paranitraniline:—There are more concerns producing this material at present than formerly and contracts have been placed at low figures of late; spot prices, however, are practically unchanged.

Dinitrochlorbenzol:—An improvement is noted in the demand, but it is mostly confined to small quantities, with the supply ample; and prices unchanged.

Dinitronaphthaline:—Small lot trading appears to feature the market, the demand in the aggregate is not heavy and prices are not more than barely steady.

HEAVY CHEMICALS:—Trading continued during the past two weeks along the same moderate lines that has been evident for some time. It was asserted that many of the largest consumers are covered by existing contracts, while on the other hand where contracts have terminated, buyers in many instances are not disposed to enter new agreements over the year, but shop the market, and supplies are easy among second hands at prices materially lower than those of manufacturers. Therefore little interest is manifested by consumers in forward stocks and the entire situation, so far as heavy chemicals are concerned, still seems to be controlled by second hands. Export demand has not been very active, although there seems to be more life in trading in this direction, but the anticipated volume of orders that have been looked for has yet to appear in the market. The current movement for local consumption continues mostly of a routine nature and buyers retain a conservative policy.

Soda Ash:—The item has been very much neglected during the interval. Light ash sales were of a minor character with virtually no call for dense ash in any important quantities. Bags from the warehouse sold during the week at $1.50 for carload lots, but sales of this character were few and 5 and 10 ton lots were sold at $1.65 to $1.70 ex-warehouse. There has been little call for barrel material with isolated offerings noted from the warehouse at $1.60, which was an extremely low figure, while other resale lots were held at $1.70 to $1.75. Double bags were available during the week at 2c. Middle West, with material in the warehouse at San Francisco and Seattle being offered at $1.90 with no interested buyers.

Caustic Soda:—There was not much doing for this chemical, although some spasmodic activity was noted and sales were consummated through second hands as low as $2.50 for warehouse material, with 25 and 50 ton lots having sold during the week at $2.60 f.a.s. At the close some isolated offerings by weak holders were made at $2.50 ex-store, while in most instances $2.55 to $2.60 was asked for resale material. First hands were offering caustic soda at $2.80 f.a.s. early in the week, but toward the latter end were asking 3c. This advance seems to have affected the resale market, and despite the fact that offerings were liberal among second hands, there was no disposition to shade prices to stimulate business.

Bleaching Powder:—Producers continue to report a moderate inquiry for this commodity for export purposes and keen competition between second hands and producers alike has resulted in some lively bidding to close business. Some sales were consummated at low levels, by second hands, who still seem to be in a position to offer below manufacturers' figures. First hands were offering fresh material in export drums at $1.75 f.a.s., while domestic drums were quoted at $1.40 Niagara.

Bichromate of Soda:—Conditions in this market show no indication of any firming up in the situation, with sales for outside brands noted during the week at 8c. for spot material. Standard brands were offered by second hands at 9c. to 9¼c., while manufacturers were making an effort to keep the market up at 9½c.

Bichromate of Potash:—Although the present rate of absorbing stocks is having no effect on available supplies, producers report a slightly better movement for the product, particularly for export purposes, while local purchasing is apparently confined to immediate needs. In this instance the resale market offers material at 33¾c. ex-store or f.a.s., which is ¼c. lower than prices quoted by manufacturers.

Chlorate of Potash:—The recent lack of demand has had its effect in this market, with sales reported as low as 27c. for material for immediate shipment from the works, while spot material was offered at 29c., which was a decline of 4c.

Bicarbonate of Soda:—While there has been nothing in the way of any important trading passing for this commodity, there seems to be a sufficient call for the product to take the slack off the market. Stocks, however, are more than sufficient for the current call, but have not accumulated in any large surplus. Barrels at the works were offered at $2.30, while spot material was available at from $2.35 to $2.40. Kegs were quotably unchanged in price at $2.65 ex-warehouse.

Caustic Potash:—Reports of price cutting for the Western material has seemingly had no effect on the standard brand of this product, which is held firmly at 50c. for the 88-92 test, while sales of the other grades were noted as low as 40c. for the same test. Despite the variation of price, many consumers prefer the standard electrolytic product.

Chicago, May 10.

Although the connection between the Liberty Loan campaigns and the chemical market is hard to establish, it is a fact proved by previous experience that the drives have a tendency to slacken sales. The present drive for Victory Bond sales is no exception, the past two weeks showing but little activity in Chicago.

In general, conditions seem to be improving. Overstocks are gradually being used up, which is causing a gradual strengthening in the entire line of heavy chemicals. As was foreseen in the last report from this district, the bottom seems to have been reached and it is merely a question of time until all items which have been selling at less than cost of production will return to a reasonable quotation.

Caustic soda continues to be about the weakest item in the market, it still being possible to buy at an absurdly low figure, though it is showing some tendency to stiffen. Carbolic acid is still plentiful at less than cost, but it can no longer be had for the mere cost of containers. In the acids, sulphuric and muriatic have reached approximately their pre-war standing and should remain there. Ammonia and nitric acid are still slightly above the pre-war price, but seem to be inclined the same way.

Coal-tar products and their derivatives have taken an upturn, 90 per cent benzol bringing 25c. and being in fairly good demand. In this line the recently noted tendency of buyers to follow a hand-to-mouth policy is not so pronounced, the consumer who studies underlying conditions evidently being convinced that no lower prices are coming, but that, on the contrary, an increase may be definitely looked for.

Vegetable oils, particularly soap stocks, are in excellent demand, with prices firm and no reductions in sight.

Flotation Oils and Naval Stores:—Prices remain very firm with demand equal to if not in excess of supply. Steam distilled pine oil, 0.933 test pure, has registered an advance of 5c., now being sold at 75c. in barrel lots, 72c. in carloads. Lower test stuff is offered at from 4 to 6c. less. Hardwood creosote is unobtainable in this market, a bona fide purchaser last week being forced to go with his want unfilled. Turpentine continues scarce, there being sufficient to supply actual needs, however, at a firm market of 68c.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET MAY 12, 1919

Acetic anhydride	lb.	.55 —	.60
Acetone	lb.	.15½ —	.16
Acid, acetic, 28 per cent	cwt.	3.00 —	3.25
Acetic, 56 per cent	cwt.	6.00 —	7.00
Acetic, glacial, 99½ per cent, carboys	cwt.	12.00 —	14.00
Boric, crystals	lb.	.13½ —	.14½
Boric, powder	lb.	.13½ —	.14½
Hydrochloric, tech. 20 deg.	cwt.	1.50 —	3.00
Hydrofluoric, 52 deg.	lb.	.08 —	.08½
Lactic, 44 per cent. tech.	lb.	.12½ —	.13
Lactic, 22 per cent. tech.	lb.	.05½ —	.06
Molybdic, C. P.	lb.	6.50 —	7.40
Nitric, 40 deg.	lb.	.06 —	.07
Nitric, 42 deg.	lb.	.07 —	.08
Oxalic, crystals	lb.	.27 —	.30
Phosphoric, Ortho, 50 per cent. solution	lb.	.07½ —	.10
Picric	lb.	.50 —	.60
Pyrogallic, resublimed	lb.	2.55 —	2.70
Sulphuric, 60 deg., tank cars	ton	11.00 —	13.00
Sulphuric, 60 deg., drums	ton	17.00 —	.....
Sulphuric, 60 deg., carboys	ton	20.00 —	.....
Sulphuric, 66 deg., tank cars	ton	16.00 —	20.00
Sulphuric, 66 deg., drums	ton	21.00 —	.....
Sulphuric, 66 deg., carboys	ton	25.00 —	.....
Sulphuric, fuming, 20 per cent. (oleum) tank cars	ton	22.00 —	25.00
Sulphuric, fuming, 20 per cent. (oleum) drums	ton	25.00 —	.....
Sulphuric, fuming, 20 per cent. (oleum) carboys	ton	30.00 —	.....
Tannic, U. S. P.	lb.	1.40 —	1.50
Tannic, (tech)	lb.	.42 —	.60
Tartaric, crystals	lb.	.86 —	.87½
Tungstic, per lb. of WO_3	lb.	1.60 —	1.75
Alcohol, Ethyl	gal.	4.00 —	4.85
Alcohol, Methyl	gal.	1.25 —	1.30
Alum, ammonia lump	lb.	.04 —	.05½
Alum, potash lump	lb.	.08½ —	.10
Alum, chrome lump	lb.	.17½ —	.18
Aluminium sulphate, commercial	lb.	.01½ —	.03
Aluminium sulphate, iron free	lb.	.02½ —	.03½
Aqua ammonia, 26 deg., carboys	lb.	.06½ —	.09
Ammonia, anhydrous, cylinders (100-150 lbs.)	lb.	.30 —	.....
Ammonium carbonate, powder	lb.	.12½ —	.13½
Ammonium chloride, granular white (sal ammoniac)	lb.	.13½ —	.14
Ammonium chloride, granular gray (sal ammoniac)	lb.	.14 —	.16
Ammonium nitrate	lb.	.17 —	.20
Ammonium sulphate	lb.	.05½ —	.06
Amyl acetate	gal.	3.50 —	3.75
Arsenic, oxide, lumps	lb.	.09 —	.09½
Arsenic, sulphide, powdered	lb.	.30 —	.32
Barium chloride	ton	70.00 —	80.00
Barium dioxide (peroxide)	lb.	.22 —	.24
Barium nitrate	lb.	.10 —	.11
Barium sulphate (precip.) (blanc fixe)	lb.	.02½ —	.03½
Bleaching powder, (see calcium hypochlorite)		.... —	....
Blue Vitriol (see copper sulphate)	lb.	.08 —	....
Borax, (see sodium borate)		.. —	....
Brimstone, (see sulphur, roll)		.... —	....
Bromine	lb.	.55 —	.60
Calcium acetate	lb.	.04 —	.05
Calcium carbide	lb.	.05½ —	.06
Calcium chloride, fused, lump	ton	19.00 —	21.00
Calcium chloride, granulated	lb.	.02 —	.02½
Calcium hypochlorite, (bleaching powder)	cwt.	1.50 —	2.00
Calcium phosphate, monobasic	lb.	.22 —	.23
Calcium peroxide	lb.	1.50 —	1.70
Calcium sulphate, precipitated	lb.	.09 —	.09½
Carbon bisulphide	lb.	.06½ —	.08
Carbon tetrachloride, drums	lb.	.13½ —	.14½
Carbonyl chloride (phosgene)	lb.	.75 —	1.00
Caustic potash, (see potassium hydroxide)		.... —	....
Caustic soda, (see sodium hydroxide)		.... —	....
Chlorine, gas, liquid-cylinders, (100 lb.)	lb.	.06 —	.08
Cobalt oxide	lb.	1.60 —	1.65
Copperas (see iron sulphate)		.... —	....
Copper carbonate, green precipitate	lb.	.28 —	.31
Copper cyanide	lb.	.65 —	.70
Copper sulphate, crystals	lb.	.07½ —	.08
Cream of tartar, (see potassium bitartrate)		.... —	....
Epsom salt, (see magnesium sulphate)		.... —	....
Formaldehyde, 40 per cent	lb.	.21½ —	.22½
Glauber's salt (see sodium sulphate)		.... —	....
Glycerine	lb.	.16½ —	.17
Iodine, resublimed	lb.	4.25 —	4.30
Iron oxide, red	lb.	.06 —	.08
Iron sulphate (copperas)	lb.	.01½ —	.02½
Lead acetate, normal	lb.	.12½ —	.14
Lead arsenate (paste)	lb.	.15 —	.18
Lead nitrate, crystals	lb.	.85 —	.86
Litharge	lb.	.09½ —	.10½
Lithium carbonate	lb.	1.50 —	...
Magnesium carbonate, technical	lb.	.12 —	.14
Magnesium sulphate, U. S. P.	100 lb.	2.25 —	2.50
Magnesium sulphate, commercial	100 lb.	2.25 —	2.50
Nickel salt, double	lb.	.13 —	.15
Nickel salt, single	lb.	.11½ —	.14
Phosgene (see carbonyl chloride)		.... —	....
Phosphorus, red	lb.	.75 —	.80
Phosphorus, yellow	lb.	.35 —	.40
Potassium bichromate	lb.	.33 —	.35
Potassium, bitartrate, (cream of Tartar)	lb.	.55 —	.58
Potassium bromide, granular	lb.	.49 —	.50
Potassium carbonate, U. S. P.	lb.	.65 —	.70
Potassium carbonate, crude	lb.	.08 —	.14
Potassium chlorate, crystals	lb.	.35 —	.40
Potassium cyanide, 98-99 per cent	lb.	Nominal	
Potassium hydroxide, (caustic potash)	lb.	.35 —	.45
Potassium iodide	lb.	3.30 —	3.40
Potassium nitrate	lb.	.19 —	.22
Potassium permanganate	lb.	.60 —	.75
Potassium prussiate, red	lb.	.85 —	.95
Potassium prussiate, yellow	lb.	.34 —	.45
Potassium sulphate	ton	225.00 —	....
Rochelle salts (see sodium potas. tartrate)		.... —	....
Salammoniac, (see ammonium chloride)		.... —	....
Sal soda (see sodium carbonate)		.... —	....
Salt cake (see sodium bisulphate)		.... —	....
Silver cyanide	oz.	1.00 —	....
Silver nitrate	oz.	.63 —	.65½
Soda ash, light	100 lb.	1.50 —	1.55
Soda ash, dense	100 lb.	2.25 —	2.45
Sodium acetate	lb.	.07 —	.07½
Sodium bicarbonate	100 lb.	2.35 —	2.50
Sodium bichromate	lb.	.09 —	.10
Sodium bisulphate, (nitre cake)	ton	12.00 —	14.00
Sodium bisulphite	lb.	.05 —	.07
Sodium borate, (borax)	lb.	.07½ —	.08
Sodium carbonate (sal soda)	100 lb.	1.60 —	2.00
Sodium chlorate	lb.	.15 —	.18
Sodium cyanide	lb.	.30 —	.31
Sodium fluoride	lb.	.14 —	.15
Sodium hydroxide, (caustic soda)	100 lb.	2.50 —	2.65
Sodium molybdate	lb.	2.50 —	.
Sodium nitrate	100 lb.	4.07½ —	...
Sodium nitrite	lb.	.13 —	.14
Sodium peroxide, powdered	lb.	.25 —	.30
Sodium phosphate, dibasic	lb.	.03½ —	.03½
Sodium potassium tartrate (Rochelle salts)	lb.	.43 —	.45½
Sodium prussiate, yellow	lb.	.16½ —	.22½
Sodium silicate, solution (40 deg.)	lb.	.02 —	.02½
Sodium silicate, solution, (60 deg.)	lb.	.03½ —	.04½
Sodium sulphate, crystals, (Glauber's salts)	cwt.	1.25 —	1.50
Sodium sulphide, crystal, 60-62 per cent, (conc)	lb.	.04½ —	.05
Sodium sulphite, crystals	lb.	.04 —	.06½
Strontium nitrate, crystals	lb.	.25 —	.30
Sulphur chloride	lb.	.07½ —	.09
Sulphur, crude	ton	35.00 —	37.50
Sulphur dioxide, liquid, cylinders	lb.	.10 —	.12
Sulphur, (sublimed), flowers	100 lb.	3.05 —	3.15
Sulphur, roll, (brimstone)	100 lb.	2.70 —	3.10
Tin bichloride, (stannous)	lb.	.22½ —	.25
Tin oxide	lb.	.63 —	.66
Zinc carbonate, precipitate	lb.	.18 —	.20
Zinc chloride, gran	lb.	.13½ —	.14
Zinc cyanide	lb.	.49 —	.50
Zinc dust	lb.	.12 —	.13
Zinc oxide, dry American	lb.	.09 —	.11½
Zinc sulphate	lb.	.03½ —	.04

Coal Tar Products—Intermediates, etc.

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	1.00 —	1.10
Alpha naphthol, refined	lb.	1.40 —	1.50
Alpha naphthylamine	lb.	.40 —	.50
Aniline oil, drums extra	lb.	.22 —	.24
Aniline salts	lb.	.28 —	.33
Anthracene, 80% in drums (100 lb.)	lb.	.90 —	1.00
Benzaldebyde (f.f.c.)	lb.	1.30 —	1.50
Benzidine, base	lb.	1.00 —	1.15
Benzidine, sulphate	lb.	.90 —	1.10
Benzoic acid, U. S. P.	lb.	1.00 —	1.25
Benzoate of soda, U. S. P.	lb.	1.00 —	1.25
Benzol, pure, water-white, in drums (100 lb.)	gal.	.22 —	.27
Benzol, 90%, in drums (100 lb.)	gal.	.22 —	.27
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech	lb.	.25 —	.35
Beta naphthol benzoate	lb.	5.50 —	6.00
Beta naphthol, sublimed	lb.	.60 —	.75
Beta naphthol, tech	lb.	.50 —	.55
Beta naphthylamine, sublimed	lb.	2.25 —	2.35
Cresol, U. S. P., in drums (100 lb.)	lb.	.18 —	.....
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	1.00 —	1.02
Cresylic acid, 95-97%, dark, in drums	gal.	.90 —	.92
Cresylic acid, 50%, first quality, drums	gal.	.60 —	.....
Dichlorbenzol	lb.	.07 —	.10
Diethylaniline	lb.	2.25 —	2.50
Dimethylaniline	lb.	.50 —	.57
Dinitrobenzol	lb.	.25 —	.35
Dinitrochlorbenzol	lb.	.25 —	.28
Dinitronaphthaline	lb.	.45 —	.55
Dinitrotoluol	lb.	.38 —	.45
Dinitrophenol	lb.	.30 —	.32
Dip oil, 25% tar acids, car lots, in drums	gal.	.38 —	.46
Dipbenylamine	lb.	.70 —	.75
H-acid	lb.	1.90 —	2.25
Metaphenylenediamine	lb.	1.80 —	..
Monochlorbenzol	lb.	.12 —	.14
Monoethylaniline	lb.	1.50 —	1.75
Naphthaline, crushed in bbls. (250 lb.)	lb.	.06 —	.08
Naphthaline, flake	lb.	.07 —	.08
Naphthaline, balls	lb.	.10½ —	.11½
Naphthionic acid, crude	lb.	1.00 —	1.25
Nitrobenzol	lb.	.13 —	.15
Nitro-naphthaline	lb.	.40 —	.45
Nitro-toluol	lb.	.17 —	.20
Ortho-amidophenol	lb.	6.00 —	....
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	1.25 —	....
Ortho-toluidine	lb.	.40 —	.45
Ortho-nitro-toluol	lb.	.35 —	.50
Para-amidophenol, base	lb.	2.75 —	3.50
Para-amidophenol, H. Cl.	lb.	3.00 —	3.25
Para-dichlor-benzol	lb.	.06 —	.10
Paranitraniline	lb.	1.10 —	1.25
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenediamine	lb.	3.00 —	3.25
Para toluidine	lb.	1.50 —	1.75
Phthalic anhydride	lb.	1.75 —	2.15
Phenol, U. S. P. drums (dest.), (240 lb.)	lb.	.08 —	.09
Pyridine	gal.	$2.50 —	.....
Resorcin, technical	lb.	3.50 —	3.75
Resorcin, pure	lb.	6.75 —	7.00
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.20 —	.30
Salicylic acid, U. S. P.	lb.	.25 —	.35
Salol	lb.	.75 —	.85
Solvent naphtha, water white, in drums, 100 gal.	gal.	.20 —	.25
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.18 —	.20
Sulphanilic acid, crude	lb.	.25 —	.30
Tolidine	lb.	2.25 —	2.50
Toluidine, mixed	lb.	.45 —	.80
Toluol, in tank cars	gal.	.22 —	.24
Toluol, in drums	gal.	.23 —	.30
Xylidine, drums, 100 gal	lb.	.40 —	.45
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	.....
Xylol, commercial, in drums, 100 gal	gal.	.30 —	.40
Xylol, commercial, in tank cars	gal.	.30 —	.....

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	.36 —	.40
Beeswax, refined, yellow	lb.	.42 —	.47
Beeswax, white pure	lb.	.62 —	.65
Carnauba, No. 1	lb.	.80 —	.83
Carnauba, No. 2, regular	lb.	.65 —	.72
Carnauba, No. 2, North Country	lb.	.50 —	.55
Carnauba, No. 3, North Country	lb.	.42 —	.44
Ceresin, yellow	lb.	.16 —	.18
Ceresin, white	lb.	.18 —	.20
Japan	lb.	.15 —	.16
Paraffine wax, crude match wax (white) 105-110 m.p.	lb.	.07 —	.08
Paraffine waxes, crude scale, 117-119 m.p.	lb.	.07 —	.08
Paraffine waxes, crude scale, 124-126 m.p.	lb.	.07½ —	.08
Paraffine waxes, refined, 118-120 m.p.	lb.	.09 —	.09½
Paraffine waxes, refined, 123-125 m.p.	lb.	.09½ —	.10
Paraffine waxes, refined, 128-130 m.p.	lb.	.09½ —	.10½
Paraffine waxes, refined, 130-132 m.p.	lb.	.10½ —	.11
Paraffine waxes, refined, 133-135 m.p.	lb.	.11½ —	.12
Paraffine waxes, refined, 135-137 m.p.	lb.	.12½ —	.13
Stearic acid, single pressed	lb.	.17 —	.18
Stearic acid, double pressed	lb.	.18 —	.19
Stearic acid, triple pressed	lb.	.20 —	.22
Spermaceti	lb.	.30 —	.32

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lbs.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$0.68	
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.45	
Pine tar oil, ref., sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.,	gal.	.33	
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.	.58	
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.38	
Turpentine, crude, sp. gr., 0.900-0.970	gal.	.61	
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.24	
Hardwood oil, f.o.b. Mich., sp. gr., 1.06-1.08	gal.	.24	
Pinewood creosote, ref.	gal.	.48	

Naval Stores

The following prices are F.o.b., New York, for carload lots.

Rosin B-D, bbl	280 lb.	$12.20	—	$12.55
Rosin E-I	280 lb.	12.50	—	12.75
Rosin K-N	280 lb.	14.25	—	14.75
Rosin W. G.-W. W	280 lb.	15.25	—	15.60
Wood rosin, bbl	280 lb.	12.25	—	.....
Spirits of Turpentine	gal.	.78	—	.78½
Wood Turpentine, steam dist	gal.	.73½	—	.....
Wood Turpentine, dest. dist	gal.	.67½	—	.....
Pine tar pitch, bbls	200 lb.	8.00	—	8.25
Tar, kiln burned, bbl. (500 lbs.)	bbl.	12.50	—	13.50
Retort tar, bbl	280 lb.	13.50	—	14.50
Rosin oil, first run	gal.	.68	—	.78
Rosin oil, second run	gal.	.70	—	.80
Rosin oil, third run	gal.	.82	—	.83
Rosin oil, fourth run	gal.	.85	—	.95

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½	
70-72 deg., steel bbls. (85 lb.)	gal.	.31½	
68-70 deg., steel bbls. (85 lb.)	gal.	.30½	
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½	

Oils

VEGETABLE

Unless otherwise noted, the following prices are f.o.b., New York.

Castor oil, No. 3, in bbls	lb.	$0.21	—	$0.23
Castor oil, AA, in bbls	lb.	.24	—	.24½
China wood oil, in bbls	lb.	.17	—	.18½
Cocoanut oil, Ceylon grade, in bbls	lb.	.15	—	.15½
Cocoanut oil, Cochin grade, in bbls	lb.	.16½	—	.17
Corn oil, crude, in bbls	lb.	.18	—	.19
Cottonseed oil, crude (f.o.b. mill)	lb.	.17½	—	.....
Cottonseed oil, summer yellow	gal.	.22	—	.22½
Cottonseed oil, winter yellow	gal.	.23½	—	.....
Linseed oil, raw, car lots	gal.	1.56	—	1.58
Linseed oil, raw, tank cars	gal.	1.52	—	1.56
Linseed oil, boiled, car lots	gal.	1.58	—	1.60
Olive oil, commercial	gal.	2.10	—	2.25
Palm, Lagos	lb.	.15½	—	.18
Palm, bright red	lb.	.15	—	.16
Palm, Niger	lb.	.14	—	.15
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.18	—	.19½
Peanut oil, refined, in bbls	lb.	.22	—	.23
Rapeseed oil, refined, in bbls	gal.	1.50	—	1.55
Rapeseed oil, blown, in bbls	gal.	1.58	—	1.60
Soya bean oil (Manchurian), in bbls., N. Y.	lb.	.16	—	.16½
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.14¾	—	.15

FISH

Winter pressed Menhaden	gal.	$0.85	
Yellow bleached Menhaden	gal.	.87	
White bleached Menhaden	gal.	.89	
Blown Menhaden	gal.	.95	

Miscellaneous Materials

All Prices F.o.b., N. Y.

Barytes, domestic, white, floated	ton	$25.00	—	$36.00
Barytes, off color	ton	22.00	—	27.00
Blanc fixe, dry	lb.	.03½	—	.04½
Blanc fixe, pulp	ton	30.00	—	45.00
Casein	lb.	.17	—	.19
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.04½	—	.06
Chalk, English, dense	lb.	.04	—	.05
China clay (Kaolin), imported, lump	ton	35.00	—	.....
China clay (Kaolin), imported, powdered	ton	60.00	—	.....
China clay (Kaolin), domestic, lump	ton	10.00	—	20.00
China clay (Kaolin), domestic, powdered	ton	25.00	—	40.00
Feldspar	ton	11.00	—	15.00
Fluorspar, acid grade, lump, f.o.b. mines	net ton	35.00	—	37.00
Fluorspar, acid grade, ground, f.o.b. mines	net ton	40.00	—	45.00
Fuller's earth, domestic, powdered	ton	30.00	—	40.00
Fuller's earth, imported, powdered	ton	.....	—	....
Pumice stone, imported	lb.	.03	—	.06
Pumice stone, domestic	lb.	.02½	—	....
Shellac, TN	lb.	.60	—	....
Shellac, D.C.	lb.	.75	—	....
Shellac, V. S. O.	lb.	.75	—	.80
Shellac, Diamond I	lb.	.75	—	....
Shellac, orange, fine	lb.	.65	—	....
Shellac, orange, superfine	lb.	.67	—	....
Shellac, A.C. garnet	lb.	.60	—	....
Shellac, bleached, bone dry	lb.	.67	—	....
Shellac, bleached, fresh ground	lb.	.57	—	....
Soapstone	ton	15.00	—	25.00
Talc, domestic	ton	16.00	—	60.00
Talc, imported	ton	55.00	—	60.00

Refractories

Following prices are f. o. b. works:

Chrome brick	net ton	90–100 at Chester, Penn.
Chrome cement	net ton	45–50 at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	35–45 at Clearfield, Penn.
Clay brick, 2nd quality	net ton	30–35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50–55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in	net ton	80–90 at Chester, Penn.
Silica brick	net ton	41–45 at Mt. Union, Penn.

Ferro-alloys

All prices f. o. b. works.

Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.32	—	.40
Ferro-chrome, per lb. of Cr. contained, 2-4% carbon	lb.	.70	—	.....
Ferro-manganese, 70-80% Mn	gross ton	110.00	—	150.00
Spiegeleisen, 16-20% Mn	gross ton	40.00	—	50.00
Ferro-molybdenum, per lb. of Mo	lb.	2.50	—	3.00
Ferro-silicon, 50%	gross ton	90.00	—	115.00
Ferro-silicon, 75%	gross ton	150.00	—	175 00
Ferro-silicon, 10-15%	gross ton	50.00	—	60.00
Ferro-tungsten, 70-80%, per lb. of contained W	lb.	1.30	—	1.60
Ferro-ursnium, 35-50%, of U	lb.	7.00	—	.....
Ferro-vanadium, 30-40%, per lb. of contained V.	lb.	5.50	—	7.00

Reasles and overstocks make above prices approximate.

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	$0.70		
Chrome ore, 48% and over	unit	1.00	—	$1.25
Coke, foundry, f.o.b. mines	net ton	4.50	—	5.00
Coke, furnace, f.o.b. mines	net ton	3.75	—	4.75
Petroleum coke, f.o.b. Atlantic seaboard	net ton	16.00	—	16.50
Fluorspar, gravel, f.o.b. mines	net ton	18.50	—	20.00
Manganese ore, 45% Mn and over	unit	.50	—	.85
Manganese ore, chemical (MnO_2)	gross ton	60.00	—	70.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75	—	.85
Tungsten, Scheelite, 60% WO_3 and over per unit of WO_3	unit	9.00	—	10.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.50	—	8.00
Uranium oxide, 96%	lb.	.....	—	.....
Vanadium pentoxide, 99%	lb.	6.00	—	.....
Pyrites, foreign, lump	unit	.17	—	.....
Pyrites, foreign, fine	unit	.17	—	.....
Pyrites, domestic, fine	unit	.14	—	.....
Ilmenite, 50% TiO_2	net ton	30.00	—	.....
Rutile, 95% TiO_2	net ton	200.00	—	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	3.00	—	3.25

Reasles and overstocks make above prices approximate.

Plant Materials and Supplies

In carload lots, New York, unless otherwise stated.

BUILDING MATERIALS

Portland cement, at dock, without bags	bbl.	$2.30
Lump lime, common, including container	300 bbl.	2.65
Common brick, at dock	M.	15.00
Hollow building tile, 8x12x12	M.	194.40
At factory, Perth Amboy, N. J., 12x12x12	M.	291.60
Yellow pine, 3x4 to 8x8, 20-24 ft. long	M.	39.00
Yellow pine, 3x4 to 8x8, 0-4 ft. long at Chicago	M.	38.50
Yellow pine, 3x4 to 8x8, 20-24 ft. long at St. Louis	M.	35.00
Roofings, tar felt (14 lb. per 100 sq.ft.)	ton	50.00
Roofings, tar pitch (in 400-lb. bbl.)	ton	19.00
Roofings, asphalt pitch	ton	30.00
Roofings, asphalt felt	ton	65.00
Roofings, slate-surfaced shingles, per roll of 108 sq.ft.		2.10
Roofings, slate-finished shingles, 100 sq.ft.		5.50
Linseed oil, raw in barrels	gal.	$1.63
Linseed oil, 5 gal. cans	gal.	1.76
Red lead, dry, 100 lb. keg	lb.	.13
Red lead, in oil, 100 lb. keg	lb.	.14½
Red lead, dry, 5 lb. cans	lb.	.15
Red lead, in oil, 5 lb. cans	lb.	.16½
White lead, dry and in oil, 100 lb. keg	lb.	.13
White lead, dry and in oil, 25 and 50 lb. kegs	lb.	.13½
White lead, dry and in oil, 5 lb. cans	lb.	.15

STRUCTURAL STEEL, MILL, PITTSBURGH

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.66
Rivets, structural, ½-in. and larger	100 lb.	4.20
Rivets, conchead for boilers, ½-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.35
Sheets, No. 10 blue annealed	100 lb.	3.55
Sheets, No. 28 galvanized	100 lb.	5.70

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Arizona

AJO—S. Clark plans to build a leaching plant having a daily capacity of 50 tons at Clarkston, near here. Estimated cost, $10,000.

DUNCAN—The Goldfield Consolidated Mining Co., Reno, Nev., plans to build a 100-ton mill and cyanide plant at Ash Peak, here. C. Storr, superintendent.

GLOBE—The Gila Monster Co. plans to build a 10-stamp mill and a cyanide plant. W. H. Seaman, superintendent.

MORENCI — The Phelps-Dodge Corp., Bisbee, plans to either remodel its old plant here or build a new modern plant. M. H. McLean, mine superintendent.

MORENCI—The Stargo Syndicate plans to build a mill and a 100-ton cyanide plant. M. J. Hannon, superintendent. J. M. Callow, Salt Lake City, Utah, consulting engineer.

TUCSON—The Mineral Hills Co. plans to build a concentrator. Estimated cost, $100,000. U. A. Fritschie, manager.

California

CULVER CITY—The H. Lehrman Studios have awarded the contract for the construction of a film manufacturing plant, to the Milwaukee Building Co., 316 Wright & Callender Bldg., Los Angeles. Estimated cost, $75,000.

MODESTO—The Modesto Gas Co. plans to build a 300,000-cu.ft. steel gas holder and extend the gas mains to new sections of the city, also to build a new gas generating unit and install two purifiers. Estimated cost, $65,000.

Colorado

BOULDER—The city plans to build a filtration plant. Estimated cost, $150,000. W. D. Salter, city engineer.

VANADIUM—The Primos Chemical Co. plans to build a treatment plant for the reduction and concentration of vanadium ores, and is in the market for lumber, metal work, crushing machinery, tanks, screens, motors, belting, etc. Estimated cost, $75,000.

Florida

WINTER GARDEN—The city plans an election June 15 to vote on $75,000 bonds for water, light and sewer improvements. Plans include the construction of a septic tank and disposal plant. W. H. Reams, mayor.

Georgia

LA GRANGE—G. H. Sargent, city engineer, will soon receivs bids for the construction of a sewage disposal plant. C. L. Smith, clerk and treasurer.

Idaho

NAMPA—The city plans to extend the sewerage system and build a septic tank. Estimated cost, $80,000.

Illinois

CHICAGO—Foley & Co., 2835 Sheffield Ave., manufacturer of proprietary medicines, plans to build a 2-story addition to its existing plant, also a new 5-story, 40 x 125-ft. building. Estiamted cost, $200,000. E. R. Krause, Majestic Theater Bldg., architect.

CHICAGO—The Municipal Tuberculosis Sanitarium, Crawford and Bryn Mawr Aves., has awarded the contract for the construction of a 2-story, 57 x 123-ft. laboratory, to H. F. Friestedt Co., 327 La Salle St. Estimated cost, $75,000. Noted Mar. 15.

JACKSONVILLE—The city voted $75,000 bonds for the construction of a dam and filtration plant. E. M. Henderson, city engineer.

MADISON—The Barber Asphalt Co., Land Title Bldg., Philadelphia, Pa., plans to build a refinery here. A. L. Robinson, c/o owner, chief engineer.

WHEATON—The State Board of Health, Springfield, has approved plans for the construction of a sewage disposal plant. L. Ruddock, city engineer.

Indiana

INDIANAPOLIS—The Hook Drug Co. has awarded the contract for the construction of a 3-story building on Market and Noble Sts., to R. Baumann. Estimated cost, $18,000. Plans include the installation of laboratories, etc.

NEW ALBANY—The Calumet Fertilizer Co. plans to build an acidulating plant for the treatment of commercial fertilizers. Estimated cost, $100,000. O. Voyles, manager.

Iowa

COUNCIL BLUFFS — The city has awarded the contract for the construction of a garbage incinerator, to the Jones Garbage Crematory Co., St. Louis, Mo. Estimated cost, $16,200. C. O. Frazer, city clerk.

FAIRPORT—The Commissioner of Fisheries, Department of Commerce, Washington, D. C., will receive bids until May 26 for the construction of a laboratory building at the Biological Station, here.

WILLIAMSBURG—The city has awarded the contract for the construction of a disposal plant to Ward & Weighton, 516-517 Davidson Bldg., Sioux City. Estimated cost, $12,500. E. Lewis, city clerk.

Kansas

TOPEKA—W. L. Johnson, c/o the Wolff Packing Co., foot of Quincy St., plans to build a 1-story, 44 x 54-ft. serum plant and a 1-story, 50 x 96-ft. hog shed on Jefferson and Crane Sts. Estimated cost, $15,000. C. D. Cuthbert, 736 Kansas Ave., architect.

TREECE—The Wachusetts Mining Co., Commeree, Okla., plans to install a hand jig plant and is in the market for several hand jigs. A. Mayerhoff, manager.

Kentucky

ASHLAND—The city is having plans prepared by Alvord & Burdick, engineers, 8 South Dearborn St., Chicago, Ill., for the construction of a filtration plant having a capacity of 2,000,000 gallons. E. C. Means is chairman of the water commissioners.

LOUISVILLE—The Louisville Cotton Seed Oil Co., 1318 McHenry St., plans to rebuild its plant recently destroyed by fire, entailing a loss of $500,000.

Maryland

BALTIMORE—The State Department of Health will alter the bacteriological laboratory at 14 West Saratoga St. Address R. B. Morse, on premises.

BALTIMORE—The H. S. Wampole Co., 761 Columbus Ave., received bids for building an addition to its proprietary medicine plant on Barre and St. Peter Sts., from the B. F. Bennett Building Co., 123 South Howard St.; G. W. Tovell, Eutaw and McCullough Sts.; Rhodes & Billops, 611 Haywood St., Arlington. Estimated cost, $35,000.

HAGERSTOWN—Shaffer & Locke, 684 Pennsylvania Ave., plan to install an acetylene welding plant for aluminium, brass, copper, etc.

HANCOCK—The Maryland Glass Sand Co., Hagerstown, is building a plant at Round Top, near here, to have a yearly capacity of 60,000 tons. Estimated cost, $50,000. E. W. Funkhouse, secretary.

HIGHLANDTOWN (Baltimore P. O.)—Jones & Lamb Co., Pennsylvania and Fulton Aves., Baltimore, plans to convert the plant of the Monumental Brewery Co., on Lombard St., into a meat packing plant and oil refinery; also construct several new buildings. Estimated cost, $500,000. C. B. Comstock, 110 West 40th St., New York City, engineer.

HOMEWOOD (Baltimore P. O.)—The trustees of Johns Hopkins University received bids for the construction of a 1-story, 50 x 150-ft. laboratory, from the Consolidated Engineering Co., 243 Calvert Bldg., B. F. Bennett Building Co., 123 South Howard St.; Frainie Bros. & Haigley, 18 Clay St. Estimated cost, $50,000. Equipment for electro-chemistry and metallurgical chemistry laboratories, also for physical, organic and inorganic chemistry study and experimentation will be installed in same. F. J. Goodnow, president.

Massachusetts

CHATHAM—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of a septic tank and sewage disposal plant, here, to H. S. Roberts, 1123 Broadway, New York City, N. Y. Estimated cost, $40,925 (75 days). Noted April 1.

WILLIMANSETT — The Papermakers' Chemical Co., Main St., Holyoke, plans to build a plant for the manufacture of chemicals necessary to the paper trade and principally for purification of rosins, on Chicopee St., here. Estimated cost, $75,000. R. M. Snell, manager.

Missouri

CAMERON—The city is having plans prepared for the installation of a filtration plant at the waterworks.

ST. LOUIS—The National Barium & Chemical Co., 7338 Arlington Ave., plans to build a chemical plant near Union St. and Natural Bridge Rd. Estimated cost, $50,000. O. Virden, president.

ST. LOUIS—The Parker-Russell Mining & Mfg. Co., Laclede Gas Bldg., plans to rebuild its silica factory at 3200 Morganford Rd., recently destroyed by fire entailing a loss of $20,000. L. Parker, c/o owner, engineer.

Montana

BUTTE—The Trustees of the State School of Mines plan to build a chemical and metallurgical building. Estimated cost, $100,000.

HARDIN—The Board of Education has awarded the contract for the construction of a 3-story high school on 5th St. to the Veatch Co., Billings. Laboratory fixtures and furnishings will be installed in same. Total estimated cost, $53,000.

New Jersey

JERSEY CITY—The city has awarded the contract for building an additional wing at the City Hospital, to W. H. & T. W. Cane, Baldwin Ave. Plans include the installation of a laboratory and fumigation building. Estimated cost, $963,145.

New York

ATHENA—The town is having plans prepared by M. Vrooman, consulting engineer, Gloversville, for the construction of a water system, water filters and a pumping station, also a sewage system and a complete disposal plant.

BROOKLYN—J. Bene & Sons, 641 Dean St., have awarded the contract for the construction of a 2-story, 100 x 100-ft. chemical factory on Carlton St., to the W. Kennedy Construction Co., 215 Montague St. Noted April 1.

BROOKLYN — The Brooklyn Hebrew Home & Hospital for the Aged, Howard and Dumont Ave., plans to build a 4-story, 90 x 100-ft. addition to its home and hospital. A chemical laboratory will be installed in same. Total estimated cost, $100,000. L. Abramson, 220 5th Ave., New York City, architect.

BROOKLYN — The Maternity Hospital Society, 1666 Pitkin Ave., plans to build a 3-story, 50 x 80-ft. hospital on Howard and Dumont Aves. Project includes the installation of a chemical laboratory. Estimated cost, $75,000. Cohn Bros., 361 Stone Ave., architects.

BUFFALO—The Mentholatum Co., 146 Seneca St., has awarded the contract for the construction of a 4-story, 80 x 100-ft. factory to the J. W. Cowper Co., Fidelity Bldg. Estimated cost, $225,000. Noted April 25.

BUFFALO—The U. S. Rubber Reclaiming Co., 784 Babcock St., has awarded the contract for the construction of a 1-story 80 x 150-ft. addition to its factory, to B. I. Crooker, Builders' Exchange. Estimated cost, $10,000.

CARTHAGE—J. Thompson, Carthage, has purchased the property between North Washington and North Clinton Sts., and plans to install sewer service to all lots

on tract, also construct a sewage disposal plant. Estimated cost, $13,500.

LONG ISLAND CITY—The General Chemical Co., 25 Broad St., New York City, has awarded the contract for the construction of a laboratory building on Washington Ave. and Halle St., here, to Leddy & Moore, 105 West 40th St., New York City. Estimated cost, $35,000.

LONG ISLAND CITY—The Liquid Carbonic Co., 624 1st Ave., New York City, has awarded the contract for the construction of a 1-story, 65 x 155-ft. factory and warehouse on Maspeth Ave., between Metropolitan and Grand Aves., to the G. A. Engineering Co., 239 Vernon Ave., Brooklyn. Estimated cost, $35,000.

NEW YORK—G. J. Adams, consulting engineer, 39 South St., is in the market for a Karl Kiefer filter with 22 cells.

NIAGARA FALLS—The Defiance Paper Co., Walnut and 3rd Sts., has awarded the contract for the construction of an addition to its pulp mill on Walnut St. to the J. W. Cowper Co., Fidelity Building, Buffalo. Estimated cost, $25,000. Noted April 15.

ROCHESTER—The city is having plans prepared for the construction of a sewage disposal plant in the 23rd Ward, to include one Imhoff tank and pumping system to care for the territory between Lata Road and Beach Ave.; also one in the Maplewood District, to include sprinkler filters. Address J. F. Skinner, assistant city engineer.

SYRACUSE—The city plans to build a garbage disposal plant. H. C. Allen, city engineer.

WAUSAU—The Chamberlain Paint & Oil Co. plans to build an addition to its present plant and install additional paint grinding and manufacturing machinery.

North Carolina

HIGH POINT—The city has awarded the contract for installing filtering apparatus and filters at the proposed water plant, to R. K. Stewart & Son, Farmville, Va., at $59,930, and the Pittsburg Meter Co., First National Bank Bldg., Pittsburgh, Pa., at $21,400.

Ohio

CLEVELAND—The Foster Manufacturing Co., 2113 East 79th St., has awarded the contract for the construction of a 1-story, 51 x 85-ft. sheet metal factory at 7600 Carnegie Ave., to I. Brygnons, 3505 Woodland Ave. Estimated cost, $6000.

CLEVELAND — The Ko-Ko-Mar Co., Leader-News Bldg., plans to remodel the brewery on West 46th St. and Train Ave. into a food products plant. Estimated cost, $40,000. A. C. Bishop, 427 Guardian Bldg., architect.

DOVER—The Tuscarora Rubber Co., c/o the W. C. Owen Engineering Co., engineers, 1900 Euclid Bldg., Cleveland, plans to build a 3-story rubber factory here.

Oklahoma

DOUTHAT—The Admiralty Zinc Co. plans to install a new sand jig and is in the market for one set of jig irons and one set of chat rolls. W. B. Shackelford, general manager.

DOUTHAT—W. Dudley plans to build a tailing mill to handle sand tailings from Admiralty Mill No. 2 and is in the market for six tables, motor, set rolls and belting.

DUNCAN—The city has awarded the contract for the construction of a sewage disposal plant to L. H. Haas. Estimated cost, $7556.

HENRYETTA—The city voted $310,000 bonds for waterworks improvements, to include the construction of a filtration plant, settling basins, supply line and distribution system. H. M. La Rue, superintendent of water works. Burns & McDonnell, Interstate Bldg., Kansas City, Mo., engineers.

HOCKERVILLE—The Prospectors Mining Co. plans to move its mill from Aurora field and erect same at Hockerville, and is in the market for an engine, boiler, rock drills and tables. W. Crawford, superintendent.

Pennsylvania

PHILADELPHIA—The Liquid Carbonic Co., 3100 South Kedzie Ave., Chicago, Ill., plans to build a 2-story, 60 x 108-ft. factory here. J. J. Novy, 3223 West 22nd St., Chicago, Ill., architect.

South Carolina

COLUMBIA—The Carolina Veneer Co., Tobacco St., plans to rebuild its plant recently destroyed by fire. J. E. Kocha, president and treasurer.

Texas

DALLAS—The Bell & Blake Co., 118 Field St., plans to install two 20-ton Scott furnaces for recovering quicksilver from Cinnabar ores.

LONGVIEW—The Texas Leasing & Development Co., Wichita Falls, plans to build an oil refinery having a daily capacity of 10,000 bbl.

WACO—The Arrow Refining Co., Suite 2010 Amicable Bldg., plans to build an oil refinery having a capacity of 5000 bbl. Estimated cost, $300,000. C. S. Dawley, president.

WICHITA FALLS—The Meridian Gasoline Co., organized by J. F. Darby, 408 New Daniels Bldg., and W. K. Campbell, 1644 South Denver St., both of Tulsa, Okla., and others, plan to build a casing-head gasoline plant here. Estimated cost, $200,000.

WICHITA FALLS—The Texhoma Oil & Refining Co. has acquired the oil refinery of Fisher & Gilliland, and plans to increase the daily capacity of same from 1200 to 2000 bbl.

Virginia

NORFOLK—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of galvanizing plant here to the W. Linker Co., 831 Cherry St., Philadelphia, Pa. Estimated cost, $119,000. Noted April 15.

West Virginia

CHARLESTON—J. S. Lakin, of the State Board of Control, will receive bids until May 22 for the construction of a sewage-sedimentation tank, sprinkling filter, sludge bed and chlorinating plant. C. E. Collins, Drexel Bldg., Philadelphia, Pa., consulting engineer.

CLARKSBURG—The Lafayette Glass Co. plans to rebuild its plant recently destroyed by fire, entailing a loss of $300,000.

WHEELING—The city plans an election soon to vote on a bond issue for the construction of a filtration plant, to be series of mechanical rapid rate pumps. Chester & Fleming, Union Bank Bldg., Pittsburgh, Pa., engineers.

British Columbia

ANYOX—The Granby Consolidated Ore Co. plans to build a plant. Estimated cost, $50,000.

VICTORIA—The Department of Mines plans the construction of a building for mineralogical experiments. Estimated cost, $200,000.

Ontario

LARDER LAKE—The Associated Gold Fields of Larder Lake plan to build a mill and are in the market for machinery for the mill and cyanide plant, motors, etc. Estimated cost, $600,000. A. Diampre, superintendent.

Coming Meetings and Events

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its Summer meeting at Boston, Mass., June 18-21. A symposium is planned on electric furnaces.

THE AMERICAN IRON & STEEL INSTITUTE will hold its next meeting on May 23-24 at the Hotel Pennsylvania, New York.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its 22nd annual meeting at Atlantic City, N. J., June 24-27. The headquarters will be at the Hotel Traymore.

THE AMERICAN ZINC INSTITUTE will hold its annual meeting at St. Louis, Mo., June 9-10.

THE FRANKLIN INSTITUTE will hold a meeting on May 21 at which the presentation of the Franklin Medal to Major-General James Douglas McLachlan on behalf of his Britannic Majesty's Government for Sir James Dewar will be given, together with the presentation of the Franklin Medal to Major-General George Owen Squier of the United States Army.

THE NATIONAL FERTILIZER ASSOCIATION will hold its 26th annual convention the week of June 23 at the Hotel Griswold, Eastern Point, New London, Conn.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its Spring meeting, June 11-14 inclusive.

Industrial Notes

THE CHEMICAL FOUNDATION, INC., which was organized at the suggestion of the Alien Property Custodian for the purpose of purchasing and exploiting chemical patents and trade marks previously owned by Teutonic interests in this country, has leased the entire fourth floor from the Irving Trust Co. at 81-83 Fulton St., for a long term of years. The new headquarters of the Foundation will be made a center for research for the advancement of chemistry and its allied sciences and their application to manufacturing purposes in the United States.

KARL S. REINHARDT announces the removal of his office from 1210 Yeon Bldg. to the Worcester Bldg., Portland, Ore.

THE HOHMANN-NELSON CO. has been organized at Eau Claire, Wis., for the manufacture of temperature, pressure, time and level controllers and recording thermometers and gages for industrial processes. The officers of the company are A. B. Hohmann, president, A. J. Nelson, vice-president and secretary, and Edward Hutchens, treasurer.

THE STEPHENS-ADAMSON MFG. CO., Aurora, Ill., has appointed Fred W. Wells as assistant engineer of the New York district office. Mr. Wells was associated with this company prior to his entering the service early in the year 1918. He was appointed first lieutenant in the 26th Engineers, served in various sections of France and with the first army during the Argonne-Meuse operation.

THE TALC PRODUCTS CO., INC., has been formed by a group of Los Angeles men with offices in the Washington Bldg., Los Angeles, Cal., to engage in the manufacture of metal-workers' crayons from white rock talc. Mr. H. N. Thomson is president of the company.

THE BROWN CO., Portland, Me., has been granted a writ of certiorari by the U. S. Supreme Court in the so-called hydrogenated oil case. This litigation, which is to determine the scope or validity of the Burchenal patent, owned by Procter & Gamble, has so far resulted in a decision for the defendant in the District Court and a reversal in the Appellate Division. The Supreme Court will now pass upon the question, which is said to be the first patent case of the kind to come before them.

THE AMERICAN STEAM CONVEYOR CORP., Chicago, Ill., announces the appointment of Mr. N. B. Stewart as district representative in charge of its St. Louis territory. Offices have been opened at 708 Merchants-LaClede Bldg., St. Louis, Mo.

THE COMMERCIAL ELECTROLYTIC CORP., New York City, announces the removal of offices from 55 Liberty St. to 527 Fifth Avenue.

THE TECHNICAL PRODUCTS CO., INC., and the HERCULES ENGINEERING CORP., of 501 Fifth Ave., New York, announce the appointment of Mr. A. B. Curtis, Jr., as Western manager with headquarters at 728 Monadnock Bldg., Chicago, Ill.

THE NEW JERSEY ZINC CO. announces the appointment of Mr. E. V. Peters to succeed Mr. H. C. Clopper as head of the sales department.

THE LUNKENHEIMER CO. announces that after May 1, 1919, the New York branch will be located at 129-135 Lafayette St.

THE NATIONAL BANK OF COMMERCE IN NEW YORK has opened an office in London, at 17 Sherborne Lane, King William St. Mr. Kenneth H. Rockey is in charge.

THE AMERICAN ZINC, LEAD & SMELTING CO., with offices in St. Louis, New York and Boston, has arranged with the American Zinc Sales Co. to handle the Azo zinc oxide in Chicago and adjacent territory. The latter company has offices at 1415 Conway Bldg. under the management of Mr. A. C. Eide. Mr. Eide previously had an active part in the technical development of processes for the manufacture of zinc oxide.

THE JOSEPH DIXON CRUCIBLE CO., Jersey City, N. J., held a meeting on April 21 at which the following officers were elected: President, George T. Smith; vice-president, J. H. Schermerhorn; secretary, Harry Dailey; treasurer, William Koester; assistant secretary and assistant treasurer, Albert Norris. Announcement is made of the removal of the Philadelphia sales office of the company from 1020 Arch St. to Rooms 801-802, Finance Bldg. This office is under the direction of Mr. W. G. Stringer.

THE CELITE PRODUCTS CO. announces the appointment of Mr. Frank Bethune, 808 Perdido St., New Orleans, La., as repre-

sentative for the Louisiana and Mississippi district. A warehouse stock will be carried to insure prompt deliveries of Sil-O-Cel ick, powder and cement for insulation, also Fiber-Cel for filtration. Mr. Ward D. Dygert has been appointed Detroit representative with headquarters in the Book Bldg.

THE FRENCH & AMERICAN BANKING CORP., representing an alliance of French and American banking interests with combined resources of over one and a quarter billion dollars, has been incorporated to promote trade between France and the United States. The incorporators are James S. Alexander, president of the First National Bank of Boston; Maurice Silvester, American representative of the Comptoir National d'Escompte de Paris, and others. Mr. Silvester will be president of the new company. There will be twelve directors, six to represent the American group and six the French group.

THE AMERICAN CHAMBER OF COMMERCE IN LONDON announces the appointment of Mr. George P. Toby as executive secretary. Mr. Toby spent over a year in Washington on plans for co-operation between the various Government departments and the business world. His work as investment banker has also given him knowledge of commercial possibilities that will be of value to American manufacturers who desire to engage in export trade. It is desired that the American manufacturers, merchants and exporters should learn to look upon the American Chamber of Commerce in London as an overseas service bureau to promote American business.

THE WILKENS & ANDERSON CO. announces the new location of general offices at 213-215 Desplaines St., Chicago, Ill.

New Publications

DESIGN OF CONCRETE MIXTURES. By Duff A. Abrams. Published by the Structural Materials Research Laboratory, Lewis Institute, Chicago, Ill.

TUNGSTEN, CINNABAR, MANGANESE, MOLYBDENUM, AND TIN DEPOSITS OF IDAHO. By D. C. Livingston, with notes on the antimony deposits, by Francis A. Thomson. University of Idaho, School of Mines Bull. No. 2, Vol. XIV.

ANALYSIS AND TESTS OF RIGIDLY CONNECTED REINFORCED CONCRETE FRAMES. By Mikishi Abe. Bull. No. 107, Engineering Experiment Station; The College of Engineering and Engineering Experiment Station, a pictorial description; A Discussion of the Development and Needs of the College of Engineering and the Engineering Experiment Station of the University of Illinois, Vol. XVI, No. 12. The above are published by the University of Illinois, Urbana, Ill.

A SUMMARY OF MINING IN THE STATE OF WASHINGTON. By Arthur Homes Fischer, Engineering Experiment Station Series, Bull. No. 4, published by the University of Washington, Seattle, Wash.

BIENNIAL REPORT OF THE STATE GEOLOGIST, 1917-1918. Published by the North Carolina Geological and Economic Survey, Raleigh, N. C.

COMMERCE MONTHLY is the title of a booklet on commerce and finance, the initial issue of which has just been published by the National Bank of Commerce in New York. The purpose of the magazine is "to serve as a medium through which the experience and investigations that have proved useful to this bank in the fields of industry, commerce and finance may be shared with its friends." It is announced that the table of wholesale commodities prices, the money market and the market letter will be regular features of the publication.

NEW BUREAU OF STANDARDS PUBLICATIONS: Circ. 24, entitled "Publications of the Bureau of Standards," 5th edition, issued April 14, 1919. This circular gives titles of all four series—scientific papers, technologic papers, circulars and miscellaneous publications. The list is numerically arranged in each series and each title is accompanied by an abstract. A full index facilitates reference to publications on specific subjects; Circ. No. 77, Table of Unit Displacement of Commodities. Issued Mar. 10, 1919; Circ. No. 79, Electrical Characteristics and Testing of Dry Cells, issued April 25, 1919; Special Agent Series No. 175 is on Construction Materials and Machinery in South American Countries. The pamphlet has been prepared to give information regarding the requirement for all kinds of construction material and machinery in Chile, Peru and Ecuador. Copies are obtainable from the Supt. of Documents, Government Printing Office, Washington, D. C., at 20c. each.

THE U. S. DEPARTMENT OF LABOR, U. S. TRAINING SERVICE. Bull. No. 7 on Industrial Training and Foreign Trade; Bull. No. 6, Labor Turnover and Industrial Training.

THE FEDERAL BOARD FOR VOCATIONAL EDUCATION has issued a series of Opportunity Monographs. Series No. 23, Commercial Occupations; Series No. 25, Occupations in the Electrical Manufacturing Industries; Series No. 22, Teaching as a Vocation; Series No. 21, Farm Management as a Vocation; Series No. 29, Occupations in the Automobile Manufacturing Industry; Series No. 19, The Lumber Industry and No. 18, Journalism as a Vocation.

NEW UNITED STATES GEOLOGICAL SURVEY PUBLICATIONS: I:18, Gold, Silver, Copper, Lead and Zinc in Idaho and Washington in 1917, Mines Report. By C. N. Gerry (Mineral Resources, 1917, Part 1), published April 3, 1919; I:19, Gold, Silver, Copper, Lead and Zinc in Arizona in 1917, Mines Report. By V. C. Heikes (Mineral Resources, 1917, Part I), published April 1, 1919; I:17, Quicksilver in 1917. By F. L. Ransome, with a Bibliography. By I. P. Evans (Mineral Resources, 1917, Part 1), published March 18, 1919; II:27, Mineral Water in 1917. By Arthur J. Ellis (Mineral Resources, 1917, Part II), published April 21, 1919; I:20, Iron Ore, Pig Iron and Steel in 1917. By Ernest F. Burchard (Mineral Resources, 1917, Part I), published April 2, 1919; II:1, Fuel Briquetting in 1918. By C. E. Lesher (Mineral Resources, 1918, Part II), published April 30, 1919.

NEW U. S. TARIFF COMMISSION PUBLICATIONS: Japan—Trade During the War and Costs of Production in the Sugar Industry.

NEW BUREAU OF MINES PUBLICATIONS: Bull. 166, A Preliminary Report on the Mining Districts of Idaho. By Thomas Varley, Clarence A. Wright, Edgar K. Soper and Douglas C. Livingston; Bull. 169, Illinois Mining Statutes Annotated. By J. W. Thompson, including Illinois Mining Laws; Tech. Paper 178, Notes on Lignite, its Characteristics and Utilization. By S. M. Darling; Tech. Paper 207, Combustion Experiments with North Dakota Lignite. By Henry Greisinger, C. E. Augustine and W. C. Harpster; Tech. Paper 209, Traps for Saving Gas at Oil Wells. By W. R. Hamilton; Tech. Paper 213, Quarry Accidents in the United States During the Calendar Year 1917. Compiled by Albert H. Fay; Tech. Paper 218, Boiler Water Treatment. Reprint of Engineering Bull. No. 3, prepared by the U. S. Fuel Administration in collaboration with the Bureau of Mines; Tech. Paper 219, Combustion and Flue Gas Analysis. Reprint of Engineering Bull. No. 4, prepared by the U. S. Fuel Administration.

Manufacturers' Catalogs

THE FOAMITE FIREFOAM CO., New York City, has issued a catalog entitled "60 Seconds—And Out!" which illustrates and describes the use of Foamite Firefoam for putting out fires at oil plants, garages, etc.

THE WILL CORPORATION, Rochester, N. Y., has published a complete catalog of laboratory glassware, representative lines of porcelain ware and the fused silica product known as vitreosil.

THE AMERICAN STEAM CONVEYOR CORP., Chicago, Ill., has published a booklet on the ash-handling problem, describing a steam jet ash conveyor.

THE TAYLOR INSTRUMENT COMPANIES, Rochester, N. Y., call attention to a general industrial catalog of Tycos instruments which is now ready for distribution. This new publication describes the whole line of Tycos instruments for the indicating, recording and control of temperature.

THE ELECTRIC FURNACE CO., Alliance, Ohio, has just received from the press Booklet 5B on Baily electric furnaces for melting brass. This 24-page booklet illustrates and describes a few typical installations and also attempts to answer questions that relate to fuel cost, reliability of essential furnace parts, foundry conditions, quality of metal produced and comparative metal losses.

THE VULCAN SOOT CLEANER CO., Du Bois, Pa., announces a new leaflet on Vulcan soot cleaners for return tubular boilers, which describes model "M," front end type, and model "Rb," rear end type. It shows how the cleaner is installed in settings of typical construction and gives the results of tests conducted by the engineering department of the University of Illinois, and by the Iowa Soldiers' Home at Marshalltown, Iowa.

THE MORSE CHAIN CO., Ithaca, N. Y., has issued a booklet on chain drives which is an illustrated article reprinted from the National Association of Cotton Manufacturers' 1919 Year Book.

THE MAGNETIC MANUFACTURING CO., Milwaukee, Wis., calls attention to Bull. L, on its type "L" magnetic separator.

THE PORTABLE MACHINERY CO., INC., Passaic, N. J., calls attention to a folder replete with illustrations showing the various uses of the scoop conveyor, describes the labor, time and money saving features of the machine in storing, reclaiming, loading and unloading material such as coal, coke, ashes, sand, gravel, crushed stone, fertilizer, cement, chemicals, etc. Copies will gladly be sent upon request.

Stocks and Bonds

Closing Bid and Asked Quotations May 12, on N. Y. Stock Exchange

CHEMICAL COMPANIES

	Bid	Ask		Bid	Ask
Am.Ag.Ch....	109¼	110½	Mat.Al.Wk..	31	40
do.pf.....	101	102	Ten. C. & C..	14⅛	15
Barrett Co....	132	134½	Un. Dyewood.	50	61
do.pf.....	115	120	do. pf.....		967
Gen.Chem....	170	178	Va.-Car. Ch..	60	66⅛
do.pf	102½	103½	do. pf.....	111	113
Int.Ag.Cb....	24½	25			
do. pf.....	81½	82			

Bonds

Am. Ag. Ch., 1st cv. 5s, '28.....	99½	99½
Am. Ag. Ch., cv. db. 5s, '24.....	108½	110½
Int. Ag. Ch., 1 mtg. & col. tr. 5s, '32....	81½	82½
Va.-Car. Ch., 1 mtg. 5s, '23.....	95½	96
Va.-Car. Ch., cv. db. 6s, '24.....	101½	101⅞

PETROLEUM COMPANIES

	Bid	Ask		Bid	Ask
Asso. Oil Co..	93½	94½	P-A Pet & Tr.	88½	88½
Cal. Pet.....	32½	33	do. pf.....	153	156
do. pf.....	78	78½	Pierce Oil.....	26½	27
Col. G. & E..	48½	48½	Royal Dutch.	110½	111
Mex. Pet.....	177½	178	Sinclair O & R	64⅜	65
do. pf.....	107½	108½	Texas Co.....	275	276
Ohio Cit. Gas.	47½	47½	Tex. Pac. Ld.		
do. pf.....			Tr.....	300	400
Ohio Fuel S...	49½	50	Tidewater Oil.	245	250
Okla. P. & R..	12½	12½			

Bonds

Columbia Gas & Electric, 1 5s, '27.....	85⅜	87
Col. G. & El., std. 1 5s, '27	85¼	85⅛
Pan-Am. Pet. & Tr. 1 6s, '19-'27.....	100	
Pierce Oil, cv. db. 6s, '24.....	109½	110
Pierce Oil, cv. 5% Notes, '20.....	123	140
Sin. O. & R. 1 In.7s, '20, with stk. war.	145	152
Sin. O. & R. 1 In. 7s, '20 without stk. war.	99½	99⅜
Texas Co., db. 6s, '31	102½	103
Union Oil of Cal. 1 5s, '31	93	94
United Fuel Gas 1 mtg. 6s, ser.A, '36....	94½	97

IRON AND STEEL SECURITIES

	Bid	Ask		Bid	Ask
Am. St. F....	34½	35	Pitts.Ste. pf..	93½	100
Beth. Steel..	74	76	Rep. Iron &		
do. Sess B	74½	74⅞	Steel.....	84½	84½
do. pf., 8%.	110⅛	112½	do. pf.....	103½	103⅝
do. pf., 7%.	99	....	Sloss Sheff. I.		
Central Fdry.	15	....	& S.....	56½	57½
do. pf.....	29	....	do. pf.....	86	90
Col. F. & I...	44½	45½	Superior Steel.	39	40
do. pf.....	....	122	do. 1 pf..	94	96½
Cruc. Steel...	71½	71½	Transa. & W.		
do. pf.....	95	97	Steel.....	48½	49
Great No. Ore	45½	45½	Un. Alloy St..	46½	47
Gulf Sta. Steel	60	61	U.S.C.I.P.&F.	24½	25½
do. 1 pf....	93	95½	do. pf.....	62	64
Lack. Steel..	74½	75	U. S. Steel....	100⅜	100⅝
Mid.St.& Ord.	45½	46	do. pf.....	114⅛	114⅜
Nova Scotia			Va. Coal,I&C.	63	65
Steel.....	62½	64			

Bonds

Beth. Steel, 1 ext. gtd. S.F. 5s, '26.....	95⅞	96¼
Beth. Steel, 1 In. ref. 5s, Ser. A, '42....	88⅛	89
Beth. Steel, P. M. & I. S. F. 5s, '36.....	85	85½
Buff. & Susq. Iron, 1 S. F. 5s, '32.....	91	96
Buff. & Susq. Iron, deb. 5s, '27.....		
Cent. Found. 1 mtg. S. F. 6s, '21.....	81	84
Col. F. & I., gn. S. F. 5s, '43.....	91	95
Ill. Steel, db. 4½s, '40	84⅜	85½
Ind. Steel, 1 mtg. gtd. 5s, '52.....	96	97½
Lack. Steel, 1 5s, '23.....	96	96½
Lack. Ste., 1 con. mtg. cv. 5s, Ser. A, '50	91½	92
Mid. St. & Ord., clt. cv. S. F. 5s, '36....	88⅜	89
Nat. Tube, 1 mtg. gtd. 5s, '52.....	97½	99
Rep. I. & S., S. F. mtg. 5s, '40.....	95⅜	98
Tenn. C. & I. R.R., gn. 5s, '51.....	91½	92½
U. S. Steel, S. F. 5s, '63.....	100⅛	100⅜
Va. C., I. & C., 1 5s, '49.....	85½	85⅞

Published SEMI-MONTHLY *on the* FIRST *and* FIFTEENTH *of each month*

CHEMICAL & METALLURGICAL ENGINEERING

A *consolidation of* ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

McGRAW-HILL COMPANY, INC.
Tenth Avenue at 36th Street
NEW YORK

JAMES H. McGRAW, President
ARTHUR J. BALDWIN, Vice Presideot E. J. MEHREN, Vice President
J. MALCOLM MUIR, Vice President EDWARD CALDWELL, Treasurer
JAMES H. McGRAW, JR., Secretary

TELEPHONE, 2840 Greeley CABLE ADDRESS, Machinist, New York

WASHINGTON, Colorado Bldg. SALT LAKE CITY, Newhouse Bldg.
CHICAGO, Old Colony Bldg. PHILADELPHIA, Real Estate Trust Bldg.
SAN FRANCISCO, Rialto Bldg. CLEVELAND, Leader-News Bldg.
LONDON, 6 Bouverie St., E. C. 4. BUENOS AIRES, Calle Corrientes, 685.

H. C. PARMELEE, Editor
ELLWOOD HENDRICK, Consulting Editor
ERNEST E. THUM, Western Editor
WALLACE SAVAGE, Assistant Editor

Yearly Subscription price for United States, Mexico and United States dependencies, $3; all other countries, $4. Single Copy, 25c.
When change of address is ordered, the NEW and the OLD addresses must be given. Notice must be received at least 10 days before change takes place. No back copies for more than three months.

Copyright, McGraw-Hill Co., Inc., 1919. Entered as second-class matter July 13, 1918, at the Post Office at New York, N. Y., under the Act of Congress of March 3, 1879.

Circulation of this issue 12,200 *copies*

CONTENTS *for June* 1, 1919

Volume XX, *Number* 11

EDITORIAL
A Penalty on Western Residence 553
The First Great Step 554
The Chemical Foundation and Confiscated German Patents 554
Readjustment and Resumption 555
READERS' VIEWS AND COMMENTS
Flaky Structures and Their Possible Elimination. By *Alex. L. Feild—Haakon Styri* 556
The Art of Searching Chemical Literature. By *Harold Hibbert* 557
Railroad Research Work. By *Luis Jackson* 558
The American Chemists' Responsibility. By *Bernhard C. Hesse* 559
Bucher Cyanide Process. By *Robert B. Sosman* 559
Western Chemical and Metallurgical Field 559
Interallied Chemical Confederation 561
Chemical Exposition Plans 561
Civil Service Examinations for Chemists 561
Spring Meeting of the New Jersey Chemical Society 562
Census of Chemical Imports 562
Postal Penalty on Western Readers 564
Business Training for Engineers 564
Chemical Service for Latin America 564
Kingsport, Tenn., and Its Chemical Industries—I 565
Flotation for the Practical Mill Man. By *Frederick G. Moses* 571
Detecting Overheated Bearings 577
The Art of Searching Chemical Literature. By *Harold Hibbert* 578
Manganese Ore 581
Use of Army Gas Masks in Atmospheres Containing Sulphur Dioxide. By *A. C. Fieldner and S. H. Katz* 582
Flotation Experiments on Hardwood Tar Oils. By *L. F. Hawley and C. C. Ralston* 586
Determination of Uranium, Zirconium, Vanadium and Aluminium in Steel—II. By *Charles Morris Johnson* 588
Civil Service Examination 589
Temperature Observations of Heating, Quenching and Drawing of a Large Steel Forging. By *O. A. Knight and F. F. Hansen* 590
Metallic Coatings for Rust-Proofing Iron and Steel—III. Bibliography. By *Henry S. Rawdon, M. A. Grossman and A. N. Finn* 591
Imports and Exports 593
Synopsis of Recent Chemical and Metallurgical Literature 594
Recent Chemical and Metallurgical Patents 596
Centrifugal Agitator and Distributor. By *Henry E. Jacoby* 598
Airtight Ashpit Door 598
Valveless Pump 599
Transformers for Electric Furnaces 600
Pipe Bending Machine 600
British Import Restrictions 600
Pershing Commends Chemical Warfare Service 601
Water-Resistant Glues 601
Book Reviews 601
Personal 602
Current Market Reports 602
Industrial News, Coming Meetings and Events, Industrial Notes and Manufacturers' Catalogs 607

A Penalty on Western Residence

ANNOUNCEMENT is made elsewhere in this issue of the increased postage that must be charged to Western subscribers of CHEMICAL & METALLURGICAL ENGINEERING beginning July 1, 1919. This extra charge is the consequence of an act of Congress which practically penalizes those inhabitants of the United States who happen or prefer to reside far from the great publishing centers of the East. The more distant the residence, the greater the penalty.

When Congress was casting about during the war for sources of revenue, in desperation and ignorance it laid the axe to the root of the great publishing business and instituted a zone system on second-class postage, under which the national magazines are carried to all parts of the country. The system provides for increased postage varying directly with the distance from the point of publication; and inasmuch as the great publishing centers of the country are mainly in the East, it follows that Western subscribers are made to bear an inequitable burden. The country is sectionalized and a barrier is raised against the uniform dissemination of knowledge and information. The greatest force in the country for molding public opinion and creating solidarity of the people is thus handicapped in its efforts, and a part of the nation is the object of discrimination.

As we have remarked on former occasions, Congress does some things well, but revenue-raising is not one of them. The egregious folly of sectionalizing the country in a matter of postage is sufficiently apparent to the simplest mind that is open to conviction, and it would seem unnecessary to marshal arguments against a tax on literacy, intelligence and desire for knowledge. The publishing business of the country is ready to bear its just share of taxation for the support of the nation, and has gladly participated in all forms of revenue-raising proposed by the Government since the war began; but it is unable to see why, under the guise of taxing publications, the burden should be laid on subscribers in accordance with their place of abode. It would be interesting to hear the reply of a Congressman to this question. It might be illuminating if an Oregon subscriber to this journal should ask his Congressman why he will be obliged to pay nearly $3 per year postage in 1921, while his more fortunate friend in New Jersey may have the same service for only sixty-eight cents. Oregon is a delightful State in which to live, but if it is cut off from participation in national enterprise and progress, it must inevitably retrograde and lose prestige as a desirable place of abode.

When the zone system went into effect, July 1, 1918, the publishers of this journal decided to absorb the first increase, and spare the subscriber the burden in the hope that Congress would repeal the law. It must be obvious, however, that this cannot continue indefinitely,

since the tax really is not on the publishing business but on subscribers depending on their residence. With the incidence of the second increase, therefore, the publishers are going to make a temporary compromise and pass the tax on to those subscribers living west of the Mississippi River. Renewed efforts are to be made to enlighten Congress, and hope is not yet abandoned that we will be successful. If we are, the charge for extra postage will be removed; if not, it must ultimately be distributed strictly in accordance with the rates established by law. In the meantime it is inconceivable that Western subscribers to this and other national magazines will refrain from voicing their views to their Congressmen; and it is equally certain that Congressmen properly approached will give heed to the combined voice of their constituency. Congressmen sometimes appear to be reasonable or unreasonable according as their political fortunes are affected. Once it is realized that the tax falls on subscribers and not on publishers we believe the light of reason will prevail.

The First Great Step

THE census of chemicals imported into the United States during the fiscal year 1913-14, prepared by the Bureau of Foreign and Domestic Commerce in collaboration with the American Chemical Society, is now ready for distribution. A digest of its features, with illustration of the manner of presentation, is given elsewhere in this issue. We commend a study of the pamphlet to every chemist of the country who has the welfare of his industry at heart. It may humble his pride, but that will do him no harm if it also stimulates his ambition.

This piece of work is the greatest single contribution ever made to the promotion of the chemical industry in the United States, for it shows in cold figures the extent of our pre-war chemical dependence on foreign countries. It stands as a monument to nearly five years of unremitting effort, and represents the co-operation of five departments of the Government—War, Treasury, Commerce, Agriculture and the Interior—besides numerous Federal boards and the American Chemical Society, which proposed and supported the plan. Never before has any Government done as much for the support of its chemical industry, and it remains to be seen what American chemists will do in response. The Government has met them more than half way, and the next move is theirs.

Let American chemists realize clearly what this census is. In effect it constitutes Exhibit A in the indictment of American chemical industry for indifferent dependence on foreign sources of crude and fine chemicals. While the achievement of its publication is a matter for congratulation, its content is in reality a measure of our country's humiliation when war revealed the appalling extent of our unpreparedness. Here, then, is no subject for rejoicing, but rather of sober meditation and firm resolution to alter the status of 1914.

It is well known now that when war dislocated world trade, the United States found that it had been dependent on Germany for a great quantity and variety of chemicals. We came to this realization over night, as it were, and a great cry arose throughout the country for chemical independence. There was much ado over the advantage our foreign neighbors had gained while we slept, and there was a call for the chemical industry to awake. It is true that American chemists arose to the war emergency and acquitted themselves with credit. But the war is now over, the emergency is passed and the future is uncertain. Fortunately this census is published at an opportune time, for it will serve as a delicate reminder of the conditions of 1914, and an incentive to create a permanent well-rounded chemical industry in this country.

Do we really want chemical independence? The answer will be found in the extent to which we diminish the number of items in this census. If we are sincere in our pretensions we will undertake to manufacture those chemicals formerly imported, and do it in as great variety and quantity as possible. We will select not only those items which are plainly profitable, but will choose also those which are functionally and economically important if not financially remunerative. We will mix some patriotism with our brains and commercial enterprise, and carry a part of the load at little or no profit until we achieve that degree of profitable independence which must be our goal.

This census has been made for the good of the whole industry and not for private advantage and exploitation. The widest use must be made of it if we are to expect further governmental co-operation. The successful outcome of this work is an earnest of what can be accomplished by the chemists if the Government is convinced that the industry will profit by it. The machinery for continuing the work is in existence and the only possible excuse for failure to perpetuate it will be a lack of interest on the part of those for whom the work was done. The first great step toward American chemical independence has been taken. Will American chemical industry take the next?

The Chemical Foundation And Confiscated German Patents

THE Chemical Foundation has great potentialities, and we take it for granted from the high character of the gentlemen engaged in the organization that it has made no serious error in taking over substantially all German patents. Patents are property, and German-owned property is confiscate in this country. There is, or rather was, much more German-owned property in America than American-owned property in Germany, so that the balance is favorable.

With these postulates granted, the measure would appear to be ethically and prudentially sound, and we shall consider only two prudential features which we hope to see solved. We shall also make one unfavorable criticism.

A number of American leaders in industry conducted great manufacturing works in Germany. Owing to the proximity of European markets and better shipping facilities in former days from German ports, they conducted large export transactions from these branches. The present measure, which of course will be abundantly reciprocated, equips the Germans with a good start in the very lines of export trade that Americans have already built up, and in considering the future of American exports we must bear in mind an important loss from this source. The problem of adjustment will be difficult, although we are hopeful of its favorable solution.

A patent is a monopoly, and its original purpose was to encourage initiative in invention, but its usefulness

has extended beyond the inventor. Industry has developed so that economical manufacture is usually possible only on a large scale. And improvements are hard to introduce. To substitute a new article for one that is old and already produced in quantity involves, usually, a hard fight, and the cost of finding a market for a new thing, even though it is greatly desired, is expensive. Perhaps this should not be so, but it is. It comes from doing things on a large scale for purposes of economy in manufacture. Therefore, for the introduction of novelties a monopoly is almost necessary for a while, until the public is informed and the art of production is mastered. The present indefiniteness of the Chemical Foundation's licenses therefore detracts from their value. We understand that it is not the intention of the Foundation to grant licenses indiscriminately, to the encouragement of destructive competition, and we hope that in the definite plans of the organization this feature may be developed to the greater encouragement of licensees.

The administrators of the Chemical Foundation have a herculean task before them and it would be churlish indeed to heckle them in their deliberations. On one point, however, we think them open to complaint, and we do not hesitate to make it. In looking over the names of the directors we fail to find a single chemist in council. So far as we are aware there is not a man familiar with chemical industry to bring chemical understanding to bear upon its acts. This seems to us a proper ground for criticism, and with all good wishes we earnestly hope that the directors may soon correct the fault.

Readjustment And Resumption

IT WAS said that the people awoke one fine morning in the early fall of 1879 to find the country prosperous. In 1899 there was a remarkable boom in practically all industries, especially marked in the iron and steel industry. There have been various arguments to account for what occurred in 1899. One cause advanced was that it was the even 20 years after the 1879 performance. Another that has been suggested, particularly by those who of late have been predicting good business because it always follows a war, is that the 1899 boom followed the Spanish-American war. Another, so ingenuously simple as to command admiration at least, was that it came after five years of industrial depression had resulted in all necessary adjustments being made. Some have even suggested that the 1899 boom was caused by the Dingley tariff of July 24, 1897.

Why could not the precise cause be assigned? The revival was largely psychological. Men got tired waiting. Conditions had become favorable some time before, but people were lethargic, unsanguine, pessimistic, hopeless. Much readjustment occurred in the years 1873 to 1876 inclusive, and in the years 1893 to 1896 inclusive, but very little in 1877 and 1878 or in 1897 and 1898. Things would have started sooner if men had not been in such a hopeless mental condition.

Today, however, we have no such unfavorable mental state. Men are hopeful, enthusiastic, anxious to get to work. The mental attitude is going to make them start too soon, if anything, certainly not too late. When these starts are made, they are made suddenly, as was the case in 1879 and in 1899. Perhaps the starts are not really sudden, but they appear so.

At the close of the war it was said that resumption of normal peace time activities would follow readjustment. That was so simple as to be quite elementary. No one undertook to inform us how far readjustment would have to extend in order that resumption could occur, hence we have been in the position of waiting for the resumption, in order to reach the interesting but useless conclusion that readjustment had been completed. It is like asking when the night will be over and being told that all we need to do is to wait until it is daylight and then we shall know that the night is past. Such information is strictly accurate but not particularly useful.

All that we have learned is that we cannot expect, as many did expect, a return to pre-war conditions as to wage rates or commodity prices. There has been enough pressure upon prices of many commodities, through restriction in demand, and upon wages, through unemployment, to cause a very considerable yielding if that were really in order, but there has been very little yielding. We cannot expect more in the second six months after the cessation of war work than has occurred in the first six months, hence the psychological phenomenon of men growing tired of waiting is likely to be exhibited almost any time. These things may come suddenly, as has been suggested by the instances cited, and particularly so when men are enthusiastic, as they must be when peace becomes established.

We have been indulging in various theories as to readjustment and reconstruction, and changing our theories as conditions changed and showed that they were unsound. No right theory for this period ever will be developed, because there is none applicable. We cannot generalize with so few facts. One theory that is about to be knocked out, if indeed it is not already knocked out, is that construction work cannot begin until construction costs are greatly reduced. We have been saying that several years of work have piled up and must be done, yet many have assumed that the work cannot begin until conditions have been made favorable for doing the whole collection of jobs. We could not do several years' work in six months anyhow, and certainly there is some work that is more pressing than others, work in which the saving of time adds a value. Some ventures are based upon a large annual return and a short amortization period, others promising smaller annual returns but admitting of a much longer amortization period in the accounting. Given a steadily descending scale of construction costs, month by month, the first named class of jobs would be undertaken sooner than the second. Again, there is work in which actual cost is not the sole consideration. One who invests in a work of construction simply to secure a profitable employment for his capital is in a different class from one who has a pet theory to carry out, or some other personal consideration. There is the man for instance who wishes a better house in which to live. His life is passing and he may not be disposed to defer building a new house for himself because there is a prospect that he would save a few dollars out of each hundred by waiting one year or two years of his life for his new house.

Resumption, therefore, is likely to come suddenly and without much warning, marking the end of the preliminary readjustment, furnishing the first definite disclosure of the amount of readjustment needed. Afterward from time to time there will be other readjustments, as it becomes necessary to pave the way for the less urgent work that is waiting to be done.

Readers' Views and Comments

Flaky Structures and Their Possible Elimination

To the Editor of Chemical & Metallurgical Engineering

SIR:—I have read with much interest the excellent paper by Prof. Haakon Styri on "Flaky Structures and Their Possible Elimination" in your May 1 issue. There are a few facts regarding the thermodynamics of the equilibria of the oxides of iron and manganese at high temperatures which I would like briefly to discuss. The method used by Mr. Styri is so simple as possibly to appear to constitute an entirely rigid treatment to those readers not familiar with the subject. Nevertheless, those same facts which prevent the treatment from possessing even theoretical exactness have occupied the attention of physical chemists for a long time, without the accumulation of sufficient data, so far, to enable the correct theory to be put into practice. I refer particularly to the rôle of specific heats in the calculation of high temperature equilibria from ordinary thermochemical measurements at room temperature.

Some time ago I had occasion to examine the literature bearing on the question of the equilibrium in the deoxidation reaction $FeO + Mn \rightleftarrows Fe + MnO$, which is, as evident, dependent upon two simple dissociation reactions, viz., $2FeO \rightleftarrows 2Fe + O_2$ and $2MnO \rightleftarrows 2Mn + O_2$. From an examination of the facts in the case it was concluded (1) that the existing specific heat data on iron, manganese and their oxides was insufficient to permit the calculation of these equilibria at high temperatures in even an approximate manner; (2) that there was no direct experimental proof that the above-mentioned deoxidizing reaction occurred, particularly in view of the existing doubt regarding the identity of ferrous oxide, FeO. Certain phases of this problem have been recently discussed by me elsewhere.[1]

Mr Styri does not call attention in his paper to the fact that the use of the approximate form of the Clausius-Clapeyron equation connecting the dissociation pressure, the heat of reaction and the absolute temperature involves the assumption that the heat of reaction is independent of the temperature. This is equivalent to taking the mean specific heat of FeO and MnO in the temperature range considered (approx. 20 to 1600 deg. C.) as equal respectively to the sum of the specific heats of Fe and oxygen and of Mn and oxygen. Le Chatelier[2] first called attention to the fact that the constant of integration in the approximate form of the Clausius-Clapeyron equation, when the dissociation pressure is 1 atmosphere, is quite often in the neighborhood of 32 in the case of simple dissociation of a solid, but that it varies some 7 units in either direction. Forcand[3] finds somewhat higher values. The subject is treated very thoroughly by Haber.[4] The use of the value 32 by Mr. Styri is probably as good a guess as any, since in the case of the oxides Fe and Mn no really reliable data are available. Even in the case of the thermochemical values for the heats of formation of FeO and MnO there undoubtedly exist considerable errors. Since LeChatelier's measurements were made (about 1896) considerable advances in calorimetry have occurred.

On page 480, Mr. Styri writes down the equation

$$\frac{p}{P} = \frac{a^2}{A^2}$$

where p = partial oxygen pressure at a concentration of FeO equal to a, P = partial oxygen pressure for a saturated solution of FeO in Fe, and A = solubility of FeO. In other words, the ratio of the partial oxygen pressures for two different concentrations of FeO is equal to the ratio of the squares of the respective FeO concentrations, at constant temperature (equal to 1600 deg. C. in this case). The next step taken is a transformation of the above equation, thus,

$$p = \frac{P}{A^2} a^2$$

Mr. Styri substitutes in this equation the values of P and A already deduced by him, and, instead of replacing A by the value for the solubility of FeO, he uses the value for the "oxygen" content of FeO, thereby making it necessary to express a in terms of the latter. He suggests the analysis of steel for oxygen as a method of determining a. Recent work by the Bureau of Standards[5] shows that the Ledebur method of determining "oxygen" in steel is of little practical value. This fact makes it certain not only that the actual oxygen content cannot be accurately determined by known methods, but also that LeChatelier's value for the solubility of FeO in steel, used by Mr. Styri in computing the constant A in the above equation, is nothing more at present than an admittedly inaccurate determination, with no intimation of how great an error may be involved. Taking into consideration all that has been said it is easy to see upon exactly what sort of experimental data the curves given in the chart on page 481 are based, and by what type of approximate theory they have been arrived at.

The danger which may result from the use of such a chart lies in the fact that, in view of its deduction from mathematical formulæ not fully understood by the average steel man, the conclusion may be drawn by such an individual that the physical chemistry of the deoxidation and allied processes is at present a complete chapter in our knowledge, thereby giving rise to an impression that further experimentation is mere repetition. As a matter of fact, what we actually know about the reaction $FeO = 2Fe + O_2$ is relatively little compared to what we do not know. The thermodynamics of the process is well known to all students of the subject. The mathematics of the case is easy compared with the difficulties of accurate measurements at these elevated temperatures. The sooner this important fact is fully realized and the necessary amount of labor given to the experimental side, the sooner will the science of metallurgy cease to be empirical and haphazard, and leap forward to its allotted position in the front rank of applied thermodynamics and physical chemistry.

This viewpoint seems reasonable when we consider the fact that at the present time our knowledge of the specific heat of iron extends only to 1100 deg. C.[6]; and that of manganese to 500 deg. C.[7]; while the data regard-

[1] *Journ.*, Ind. Eng. Chem., Vol. 11, p. 242 (1919).
[2] *Ann. des Mines*, Series viii, Vol. 13, p. 157 (1888).
[3] *Ann. Chem. Phys.*, Series vii, Vol. 28, pp. 384, 531 (1903).
[4] Thermodynamics of Technical Gas Reactions, 3rd Lecture, 1908.
[5] J. R. Cain and Earl Pettijohn, Tech. Paper 118 (1919).
[6] *Phil. Mag.*, Vol. 10, p. 430 (1905).
[7] *Ann. Phys. Chem.*, Series Iv, Vol. 16, p. 551 (1905).

ing the specific heats of FeO and MnO are confined to measurements at room temperature. The specific heat of the common gases may be considered as fairly well established[5], even at high temperatures.

Such data as do exist, for the lower temperature ranges, show clearly that the change in the specific heats of Fe and Mn may exert a relatively great effect in determining the equilibria at high temperatures. These changes cannot be ignored. For instance, Laemmel' finds that the specific heat of Mn at 0 deg. C. is equal to 0.1072; at 500 deg. C. it is equal to 0.1652, an increase of about 54 per cent. Who can predict what is its value at 1600 deg. C. ?

To arrive at definite conclusions regarding these high temperature equilibria we must have data sufficient to make possible the use of the free energy equation in its complete form, or else succeed in making a direct determination of the equilibria. In the former case, we must have complete specific heat data, otherwise we are reduced to a state of unsubstantial assumptions and indefinite approximations. The latter solution, i.e., by direct measurement, appears extremely difficult but not entirely impossible. So far no one has attempted it in the cases under consideration.

Cleveland, Ohio. ALEX L. FEILD.

* * *

To the Editor of Chemical & Metallurgical Engineering

SIR:—It is sometimes an advantage, in order to raise discussion, not to treat a subject fully, and I am glad that Mr. Feild so strongly points out the necessity of determining the data we need for the accurate determination of the equilibria at higher temperatures. Besides the specific heat mentioned by Mr. Feild it is equally important to determine the oxygen and carbon content in equilibrium at higher temperatures and I agree that no known method for the determination of oxygen in the cold steel is satisfactory because no attention is paid to the oxygen which escapes during cooling and solidification. My statement of Pickard's analysis of 0.092 per cent O and of Shimer and Kichline's of 0.074 and 0.064 per cent O in overblown steel (by an error stated wrongly in my paper) as possibly representing the oxygen concentration in the steel for a certain slag should therefore be correspondingly modified.

In the writer's paper it was the intention to collect in as simple form as possible the influence of the different variables in steel refining. It might help others as it helped myself to get a clearer understanding of the reactions in the steel furnace and will aid in the prediction of what must happen to the steel when additions are made or the temperature changed. The value of determining the heat of combustion and the solubility of oxygen and carbon more accurately at the temperature considered will be to give the curves of my chart their correct position, which in all probability will be different from those presented, but the relative form of the curves must be the same. And even with great divergence from their correct values the curves will be useful in practice because we must remember that they represent equilibria and it will be in only extremely rare cases that such conditions are present in the steel furnace. Most of the time the conditions deviate considerably from the equilibria and we will correspondingly have different speed of reactions according to how far the system is from equilibrium; and knowing the conditions we can predict in what direction they will go.

With the unsatisfactory knowledge of the saturation concentration of oxygen at different temperatures I found it unnecessary, therefore, to try to calculate the heat of combustion at the high temperature by the help of the inaccurate specific heats, and for the same reason I refrained from publishing some otherwise interesting calculations of the influence of different slag concentrations. It was the writer's desire first to determine in actual practice how much the calculated curves would vary from concentrations found under certain conditions in the steel furnace and if possible under equilibrium conditions, and also to try to determine certain physicochemical data whereby the problem could be attacked from another angle. Both series of tests were started before the paper was published, but I regret to say that the progress has not been fast owing to lack of opportunity and time.

Mr. Feild notes the substitution of the oxygen content of FeO for the solubility A of FeO in formula 6, thereby necessitating the expression of a in the same terms. It was perhaps a little careless not to retain the numerical value of the solubility of FeO and calculate the O content from the found concentrations of FeO (a). But it is easy to see that the concentrations of FeO (A and a) vary from the concentrations of O only by a constant factor, the same in numerator and denominator, so no misunderstanding should occur since the explanation was given in advance.

The concentrations of O can just as well be used in the formula, since we do not know in which form the O is present in the liquid steel, whether combined with Fe and dissolved as FeO or dissolved as O. It is clear that whichever form it is, the partial pressure of the O must be equal to the dissociation pressure of the FeO with which it is in equilibrium, when we disregard the probably small influence of the partial pressure of Fe. HAAKON STYRI.

Carnegie Institute of Technology, Pittsburgh, Pa.

[5]See Lewis, *J. A. C. S.*, Vol. 34, p. 1128 (1912).

The Art of Searching Chemical Literature

To the Editor of Chemical & Metallurgical Engineering

SIR:—In connection with the article on "The Art of Searching Chemical Literature" in this issue of your journal, may I call the attention of the National Research Council and especially of the committee on publication presided over by Dr. Stieglitz, to the desirability of a publication which shall provide what might be called a "General Index to Chemical Literature"? This would include the "art of searching literature" and provide at the same time a full and complete list of all special monographs, theses and works of reference to chemistry.

The instructive synopses of chemical treatises published by Mr. McClellan in the bulletin of the Carnegie Library serve a very useful purpose, and if these were made to embrace the entire chemical literature they would provide a volume of especial value.

Another point of interest is that up to the present the French chemical journal literature has not been readily accessible largely on account of the lack of good indexing. It is easy to understand why German authors have invariably failed to give proper credit to French investigators, and if some one well qualified

would undertake the general abstracting and indexing of this literature it would be of valuable assistance in promoting the advance of chemical knowledge and would serve to refute to a considerable extent the exaggerated claims of German chemists in many branches of the "art of chemistry."

The writer would also like to suggest to editors of scientific journals the advisability of printing on the outside cover of each issue the initial and final page numbers. By this means the necessity of having to glance through several issues could be avoided. Incidentally this is the scheme adopted by the *Chemisches Centralblatt.*

HAROLD HIBBERT.

Mount Vernon, N. Y.

Railroad Research Work

To the Editor of Chemical & Metallurgical Engineering

SIR:—Your editorial in the issue for April 1, criticising the "complete cessation of industrial research and of the development of natural resources of the territories served by the various railways," now that the railroads are being administered by the Government, puts me in a reminiscent mood. I can write freely because I have practically retired from business and can possibly speak with some authority, as I was Railroad Industrial Development Commissioner for over twenty-five years. I originated the Railroad Industrial Department; ultimately it spread over the entire United States and has been more or less established on all continents.

I laid my plans before the management of the Chicago, Milwaukee & St. Paul Railway Co. in 1891. They were accepted, and with "We have no instructions to give, develop our territory," I started out on my mission. I had been trained in the transportation business and had a hobby for the study of political economy. I knew that the traffic and operating departments had their hands full with current business from morning until night and had little or no time for research. I resolved to take adequate time, and for the first six months did nothing but travel over the entire territory looking out of the car windows and acquainting myself with the people and resources of the line. Space forbids lengthy details. I will merely give a few instances showing general plan of operation.

Shortly after entering the service of the St. Paul I read in the newspapers that the pine had been largely cut out in several parts of Michigan, that once flourishing towns in the lumber districts were going to pieces and that substantial residences could be bought for $5 apiece as salvage. We had similar pine territory in Wisconsin. Sawmills were more and more coming in, the railroad was doing an immense and profitable business hauling lumber, but I figured this could not last and in the end we would have a bonded streak of rust. This especially threatened the Wisconsin Valley Division, which parallels the Wisconsin River. This territory was practically one forest of hardwood, pine, hemlock and some spruce. The pine lands with standing timber were rapidly rising in price and selling on stumpage basis, that is, at so much per thousand feet of estimated timber on the land. The hardwood land was selling at $3 per acre with the trees on it and the hemlock lands were almost unsalable at $3 per acre, including the standing timber. I advertised for furniture, veneer, cooperage and kindred factories; went East and canvassed manufacturers to come West; aroused the local towns to invite such factories. They were secured; the cities themselves did most of the work of securing new industries.

There were water-powers galore running to waste all along the Wisconsin River. Thomas Nash, Assistant Postmaster General, who lived at Grand Rapids, Wis., owned a water-power at Nekoosa, Wis. He told me he would put in the power as capital stock if I could get an Eastern paper manufacturer with capital to put in a paper mill. I advertised in all the paper-trade journals, went East and canvassed the manufacturers at Holyoke, Bangor and other places. Several came West to look the ground over. Nash heard what they had to say, but none of them would bite. Nash spoke to Ex-Postmaster General Vilas, a Wisconsin man. "What is the matter with us all chipping in and starting a paper mill ourselves?" said Vilas. They did. The second year the mill was paying the St. Paul road a freight bill of over $85,000; it ultimately went over $100,000 per annum. In eleven years we had eleven large paper mills on the Wisconsin River, chiefly from local capital. One city emulated the other; all I did was beat the drum.

I told our immigration agent to direct Scandinavian farmers to the cut-over hardwood lands, which were selling cheap. Hardwood stumps rot in two years. Settlers came. Pine stumps take 75 years to rot. I helped the powder companies to start dynamite squads to show owners of pine stump lands how to blow out the stumps. Then I took the hemlock lands in hand, advertised for tanneries in all the Eastern tanning sections, canvassed tanners and got a big Boston firm interested. They looked the ground over and shipped two cars of tanbark to Boston. Good! They located a large tannery at Merril, Wis. After arranging for side-track there I took the train for Chicago. En route I met Mr. Nash on the train, told him I had just located a tannery at Merril, the tanners had bought a large tract of hemlock, they would use the bark, but there being no present market for the wood it would go to waste. Not so! Said he, "Look here," showing me a paper, "we have just received our patent for making sulphite pulp from hemlock. See that I get a freight rate and I will contract for the peeled hemlock logs." We made him the rate and the logs went to the mill.

At another point because of distance the iron pyrites were unsalable. I canvassed the situation and we secured a sulphuric acid plant on the spot. Mineral, special clay and other finds were investigated, often with permanent freight results. But enough said. In 1903 I went to the Erie Railroad as Industrial Commissioner and we put new plants on that line in the next eleven years that would extend continuously on both sides of Broadway from the Battery to Spuyten Duyvil.

I believe that the Industrial Department of the Southern Railway did more for the development of the South than the Federal and State Governments combined, and so with all other railroads. I visited South America last year and found that two railroads there had Industrial Departments. I dash this off with no idea of self-laudation but merely from an interesting experience to confirm what you editorially intimate, namely, that the industrial development and research work of the railroads had its place, is creative and ought to be continued. I hold that whether the railroads are privately owned or government owned, creative departments are national wealth-producers.

LUIS JACKSON.

Upper Montclair, New Jersey.

The American Chemists' Responsibility

To the Editor of Chemical & Metallurgical Engineering

SIR:—The Bureau of Foreign and Domestic Commerce has just published a little pamphlet compiled by it in collaboration with the American Chemical Society. This marks a new and unique phase in co-operation between government agencies and our industries; it displays a wholesome spirit of practical patriotism and good citizenship born of war conditions and which must continue and grow in order that pre-war conditions of avoidable national dependence on foreign countries for things chemical may never return. The Government's labors are for the present concluded; the chemists' responsibilities have only now assumed tangible, definite and concrete form. Whether this country shall become and remain chemically as independent as possible now rests squarely upon America's chemists and not elsewhere.

The American public has declared in unmistakable manner its demand that this country be chemically independent; this pamphlet tells our chemists the name, the quantity and the value of every chemical article imported into this country in the fiscal year 1913-14 (the last peace-year) and also what proportions of each article came from the various countries supplying it. American chemists are therefore now and for the first time fully informed and in great detail concerning the nature and scope of their task. They know the individual articles, the domestic business volume of each, the unit price they have to meet in almost each case and the competing countries. The Chemical Foundation by acquiring all enemy-owned U. S. patents in these fields has made it possible for American chemists to surmount any obstacles to progress toward chemical independence offered by those patents. No matter how large an export or domestic business our chemists may hereafter build up, if they do not reduce America's avoidable chemical dependence they will not have met the thoroughly proper demand of our public. Progress in export or domestic business, no matter how great, never can offset any avoidable national chemical dependence.

The functional value of articles in our national activities must be the paramount guide in making us chemically independent; mere size or volume of business is no safe index of national importance. A few thousand dollars will supply all the optical glass in all the microscopes, binoculars and the like used in this country. A few hundred dollars worth of assorted coal-tar dyes will supply all the needs of the nation's bacteriologists. A few thousand dollars worth of assorted stabilizers will make the country's total requirements of explosives, in peace and in war, safe to handle and to transport. A few thousand dollars worth of assorted synthetic remedies will care for the needs of the nation's afflicted. Since foreigners succeeded in making us dependent on them for these things, it simply cannot be that our chemists cannot make us independent in those respects.

Yet the task thus concretely set American chemists is, from a business point of view, not an easy one. Three thousand separate articles of chemical manufacture and of national functional importance, but totalling only about $60,000 in value, or $20 per year on the average for each article, were imported in 1913-14; hundreds of like articles worth less than $5,000 a year apiece were then imported. How can this business be profitably distributed over our many chemical factories without violation of our own long-standing laws? America's chemists must solve not only the chemical details of production and application of these many items of manufacture but also the law-problems which obstruct progress. They can solve the former by themselves; whether they can afford to carry them out in competitive commercial practice or not depends upon their success in obtaining proper remedial legislation, and in this they must have sympathetic and effective co-operation from both the public and our law-makers; but the chemists must take and maintain firm and concrete initiative on both branches of this single problem; anything less than that is bound to lead to disappointment.

BERNHARD C. HESSE.

New York City.

Bucher Cyanide Process

To the Editor of Chemical & Metallurgical Engineering

SIR: In reporting the recent meeting of the American Chemical Society at Buffalo you state on page 394 that a paper on the Bucher Cyanide Process was given by R. O. E. Davis. This paper was by J. B. Ferguson of this Laboratory.

ROBERT B. SOSMAN,
Acting Director.

Geophysical Laboratory,
Washington, D. C.

Western Chemical and Metallurgical Field

Oxidized Copper Ores in Arizona

ONE reads in the annual reports of Arizonan corporations such statements as the following (Inspiration): "Oxide copper in mill feed 0.291 per cent; oxide copper in mill tailings, 0.253 per cent." Such a condition of affairs has caused general interest in some method whereby this elusive portion of the ore may be saved at a profit, to say nothing of its obvious application to the enormous known deposits of oxidized mineral.

A judicious combination of flotation and gravity concentration is apparently capable of making excellent recoveries of copper sulphides even in low grade ores—it may be rather unfair to quote 88.51 per cent from the Inspiration report as a mark to aim at. Consequently considerable attention has been given to "sulphidizing flotation," where by means of various reagents the oxidized particles are changed superficially to sulphides to a sufficient extent that they may be picked up by the bubbles in a flotation cell. Such a scheme was used at Hurley in the Chino Copper Co.'s mill with considerable success during the latter part of 1917. Also at Superior, the Magma company has been conducting careful and large-scale experiments with good results on the flotation of its oxidized ores. Whether the ore at Superior is more amenable to sulphidizing flotation than the general run of Southwestern ores is a matter of question—it is probable, however, that general adoption of this process will await its perfection to the point where a little inattention or a little incompetency will not throw the entire system out of balance. In other words, the impression exists that sulphidizing flotation is a delicate process which cannot yet be trusted to the average mill man.

Leaching is the apparent alternative. The only commercial operation in Arizona is at Ajo, but the signal success of this well-designed plant has strongly attracted other men with like problems to solve. Sulphuric acid, the solvent used at Ajo, is comparatively cheap and

can usually be manufactured locally from pyritic ores, while methods of precipitating copper sulphates either by electric current or on iron are quite efficient and perfectly well known by many operators. In an ore-body such as that of the New Cornelia Co., whose major mineral content is oxidized, it is obviously good engineering to leach out the acid-soluble mineral from coarsely ground ore, then follow by fine grinding to release the cleaned sulphides for flotation and gravity concentration. Movement of leach and wash solutions by displacement is feasible on granular material such as at Ajo; with finely ground material discharged from a flotation cell, counter-current decantation methods would probably prove equally satisfactory.

However, such fine tailings containing considerable quantities of clay or other like substances as experimented on at Clifton by the Arizona Copper Co. may involve the addition of so much expensive wash water as to eliminate profits altogether from the leaching operation.

While sulphuric acid is a good solvent for copper, it also attacks many other constituents of an ore to a greater or less extent, with the result that the solutions will become quickly fouled, among other undesirable effects causing a heavy loss in acid. Fortunately, experiments on 10-ton lots of Inspiration ore show it to be extremely well adapted to treatment by the Ajo system; i.e., leaching out oxides, fine grinding the residue and then floating sulphides. Following that company's semi-laboratory experiments, a unit with 35 tons daily capacity is nearing completion wherein complete information as to eventual mill practice will be obtained.

Decision as to actual construction is halted to a large extent, however, awaiting the publication of the tests being made by the Miami Copper Co. in co-operation with the Bureau of Mines. An experimental plant of considerable size was built during 1918 and operated satisfactorily for some time at the end of the year. Indicated revisions and additions are now in process of installation.

Publication of the details of this process is withheld pending completion of the test and clarification of the patent situation; however, it is generally known that the process consists of digesting the pulp with roaster gases and precipitating the clarified solution on iron. Digestion may evidently precede, follow or separate flotation operations according to particular conditions.

Heap-leaching of partially oxidized ore and low-grade capping is also receiving considerable attention. Large-scale operations on old tailings and California Hill capping are under way at Bisbee, while a large heap is being built by the Chino Copper Co. Possibly the most careful experiment is by the Phelp-Dodge Corporation at Tyrone, New Mexico, where several piles of various tonnages, depths and stratification are under observation.

Generally such piles are to be leached with mine waters discharged from precipitation tanks or launders. This water contains considerable ferric sulphate, a moderate quantity of copper and may be slightly acidulated—it is distributed over the surface of the pile—and after percolation is drained off to a recovery system. Periods of leaching and oxidation alternate, much after the methods used for years on tailings piles and ore heaps in Montana and Rio Tinto.

Beet Sugar in Utah and Idaho

Beet-sugar production in Utah and Idaho was discussed by men prominent in the industry at the April meeting of the Utah Society of Engineers. Sugar has recently sprung into great prominence in the two states, there being at present 23 factories in operating order and two more in course of construction, representing an investment of approximately $50,000,000, of largely local capital, this value being further augmented by agricultural land holdings, cattle and railroads. During the 1918 campaign about 2,750,000 bags of sugar (100 lb. each) was produced, valued at $24,500,000. Items of approximate cost production follow:

Sugar beets, 1,250,000 tons	$12,500,000
Coal, 160,000 tons	600,000
Lime rock, 100,000 tons	140,000
Coke, 12,500 tons	100,000
Bags, repairs, and miscellaneous items	1,750,000
Freight	1,250,000
Taxes	350,000
Payroll	3,500,000

Utah and Idaho factories are relatively small, having a cutting capacity of from 350 to 1200 tons of beets per day. As is possibly well known, sugar manufacture is not a complex operation; juices are extracted from the shredded beet, purified and evaporated, the sugar separated from molasses, then washed, dried and sacked. Chemical engineering problems are therefore confined largely to the handling of large quantities of hot solutions—which is almost universally done by closed impeller double-suction centrifugal pumps with a very deep stuffing box—and the evaporation of correspondingly huge volumes of water. Multiple-effect evaporators (3, 4, or 5-stage), with either vertical or horizontal tubes, are used for preliminary concentration, while crystallization is done in separate vacuum pans or candelaria. Naturally great attention is given to minimizing extraction- and wash-water and to boiler practice—sugar houses will have about 3 rated horsepower in tubular boilers capable of continuous large overload for each ten-day capacity. One pound of sugar requires from 0.9 to 1.3 lb. of bituminous coal for its manufacture, depending upon the efficiency of the thermal transfer and the sugar content of the beet.

Problems in industrial economy are dependent upon the fact that bulky beets should not be hauled great distances to a factory, on account of freight charges and the constant loss of sugar after digging. Small factories are therefore situated centrally in their contributing fields. Nine months out of the year the factory is closed and satisfactory part-time labor is rare during harvest time.

Sugar beets in proper quantity and quality represent the biggest problem of all. Here the factories are entirely dependent upon the farmers, and have only now awakened to the value of their good-will—or rather, the cost of their ill-will. Despite a large increase in price per ton paid the farmers, the sugar content is steadily falling to a dangerous minimum, while the shrinkage between wagon-scale and factory has nearly doubled in the last three years. For instance, whereas one of the larger Utah companies then received 6 per cent less beets than it paid for, last year it received about 11 per cent less. Doubtless a good share of this loss is due to natural shrinkage by evaporation of moisture and inversion of sugar by processes accompanying sprouting, still this particular company figured that it paid the farmers $260,000 in 1918 for their ill-will, for unwar-

rantable shrinkage caused by practices best known to the farmer himself.

Certain difficulties attend the successful maintenance of a schedule with beet farmers similar to that imposed upon metal miners. Doubtless perfectly satisfactory sampling methods could be worked out so that the farmer could be paid for the sugar actually delivered in the beet, but experience proves the unpopularity of this sort of contract. Farmers are in a somewhat different position from miners—if the latter do not care to accept the smelter schedule, about the only thing they can do is pack up and move into some other work. On the other hand, if a farming community decides not to raise beets, it simply plants a kitchen garden, and raises hay or grain. In other words, the sugar factory can be starved much more quickly than can the farmer.

Because of such considerations, corporation officials are seriously attempting to mold sentiment in their favor by all possible means. Co-operative profit-sharing even appears in the distance.

Interallied Chemical Confederation

THROUGH the initiative of the Société de Chimie Industrielle, an interallied chemical meeting, composed of delegates from Belgium, France, Great Britain, Italy and the United States, was held in Paris April 14, 1919, for the purpose of organizing an interallied chemical confederation. The American delegates were: Mr. Henry Wigglesworth, chairman; Dr. F. G. Cottrell, representing the National Research Council and the American Electrochemical Society; Lt.-Col. Bartow, of the American Institute of Chemical Engineers; Messrs. John Pennie and Charles MacDowell, counselors at the Peace Conference; Lt.-Col. Zanetti, Lt.-Col. Norris, Major Colin MacKall, Lt. Sidney Kirkpatrick and Mr. Donald Riley, representing the American Chemical Society.

A number of private meetings were held, presided over by Prof. Charles Moureau, president of the French Federation of Chemical Associations, at which were adopted the articles and by-laws of the Interallied Chemical Confederation for a close co-operation among Belgium, France, Great Britain, Italy and the United States. The status among the different chemical associations of the allied countries was agreed upon, and provision made for the possibility of permitting neutral countries to belong to the confederation. An interallied council board was elected, and it has been decided that the next meeting shall be held in London July 15-18, 1919.

During the public meetings of April 14-15 the following subjects were presented:

Prof. Henry Louis (Great Britain) spoke on the enrichment of iron ores by magnetic separation. Dr. Cottrell (United States) outlined American progress in the work on helium. Prof. Moureau, who was the first in France to show the existence of the sources of helium, and Mr. Georges Claude, the author of works on liquified air, presented remarks on the possible uses of helium. Mr. MacDowell (United States) spoke on the development of the American potash industry. Mr. John C. Pennie (United States) dwelt on the American patent laws, and Mr. Barbet suggested the enacting of an interallied patent law. Mr. Otlet, director of the International Office of Bibliography, closed the public meetings with an extremely interesting communication on the organization of the International Documentation.

After the customary dinners and after-dinner addresses the first interallied chemical meeting closed with a visit by the members to the devastated regions of Chauny.

The members of the council board who will meet in London next July are:

Belgium: Messrs. Chavanne and Crismer.
France: Messrs. Moureau and Paul Kestner.
Great Britain: Sir William Pope and Mr. Henry Louis.
Italy: Senator Paterno and Mr. Parodi-Delfino.
United States: Dr. Cottrell and Lt.-Col. Zanetti.

The general secretary is Mr. Jean Gerard, and the business address of the Confederation is 49, rue des Mathurins, Paris.

Chemical Exposition Plans

THE fifth annual National Exposition of Chemical Industries will be held this year in Chicago at the Coliseum and the First Regiment Armory during the week of Sept. 22, and as usual there will be a number of society meetings held jointly with it. The decision to hold the Exposition in Chicago was made unanimously by the advisory committee in consultation with the managers of the Exposition. One of the reasons for this change was the fact that the U. S. Army has commandeered Grand Central Palace for use as a hospital so that it would not be available for exposition purposes. Another reason was the keen interest shown in the Exposition by the Chicago section of the American Chemical Society, who felt that a Middle-West exposition would encourage development of the chemical industries in that part of the country. Indications are multiplying that the Exposition will be as successful as it was in New York, for all the space in the Coliseum and most of that in the Armory has been engaged.

A number of scientific and technical societies will meet in connection with the Exposition, among them being the American Institute of Mining and Metallurgical Engineers, American Electrochemical Society, American Ceramic Society and the Technical Association of the Pulp and Paper Industry. The Chicago section of the American Chemical Society will have headquarters at the Exposition and will probably hold a meeting. No other conventions will be held in Chicago that week so that adequate hotel accommodations will be available. The advisory committee and the managers of the Exposition are being assisted by a special Chicago committee consisting of Messrs. L. V. Redman, W. D. Richardson, A. V. H. Mory, Carl S. Minor, F. W. Willard and William Hoskins. The managers as in the past, are Charles F. Roth and Fred W. Payne, and the general office is at 477 South Dearborn St., Chicago, Ill.

Civil Service Examinations for Chemists

Catalytical Chemist, $3000 to $4000 a year; Assistant Catalytical Chemist, $2000 to $3000; Junior Catalytical Chemist, $1600 to $2000. Applicants for any of these positions, which are open to men only, must have had at least one year's experience in preparation and study of low temperature oxide gas catalysts.

On account of the needs of the service, applications will be received until further notice.

Spring Meeting of the New Jersey Chemical Society

IN spite of unfavorable weather about 100 members and guests of the Society met on May 10 at Rutgers College. The grounds, buildings and laboratories were inspected during the afternoon and dinner was served in Winants Hall in the evening. Prof. Ralph G. Wright, chairman of the entertainment committee, welcomed the members on behalf of the college and Johnson & Johnson, manufacturing chemists, of New Brunswick, who joined in entertaining the Society. Appropriate response was made by President Carleton Ellis. At the evening session a paper was read by Lieut. Joseph V. Meigs on the stability of automobile engine oils. By means of six well prepared experiments he showed the variation in the reaction when sulphur chloride is added to engine oils of various grades. He showed that medicinal mineral oil, being a highly refined product, reacted much more slowly than did other oils used for engine purposes. Turning to the lighter side of this subject, Lieut. Meigs said that it would be well if chemists would stand by the petroleum salesmen in their hour of trouble. One sales manager who was interested in fuel oils once stepped up to a factory chemist and asked him if it were not possible to get out an oil "that was free from carbon" because most of his customers complained that there was too much carbon in these oils. When told that some of these oils had 80 per cent of carbon in them, the excellent man went into a state of coma.

A scientific paper entitled "Oxidation and Reduction" was presented by Ernest T. Little, assistant professor of chemistry at Rutgers College. The author showed by means of carefully planned experiments that oxidation, as well as reduction, is not a molecular, but rather an electrical process. He pointed out that these two processes are influenced by four factors, namely: capacity, intensity, concentration and equilibrium. The capacity factor indicates the possibilities of oxidation for a particular oxidizing agent. The intensity factor is a measure of the strength of an oxidizing agent. It represents the driving force which determines whether or not the possibilities of oxidation are to be fulfilled. The oxidizing potential is determined by experiment and expressed in terms of volts. The concentration factor determines the potential which can be developed. Equilibrium is established when the oxidizing potentials of the reacting substances become equal to each other. In demonstrating these points, Prof. Little used a beaker (*A*) containing an oxidizing agent in acid solution and beaker (*B*)containing a salt of the lower state of oxidation (ferrous chloride). Platinum electrodes were inserted in each beaker and the terminals were attached to a delicate galvanometer. Electrical connection was established between the two beakers by means of a U-tube or salt bridge. As the oxygen passed from the permanganate solution to the ferrous chloride solution the galvanometer registered the passage of the current. The positive electricity acquired by the electrode in beaker (*A*) is carried through the anode to beaker (*B*) and there it oxidizes the iron to the ferric condition.

Members of the Society who desire to offer papers for the meetings of the Society in the Fall are asked to communicate with Dr. R. P. Calvert (chairman of the committee on program), care of Delta Laboratories, Arlington, N. J. The last meeting before the Summer will be held Monday evening, June 9, in Newark, N. J.

Census of Chemical Imports

THE census of chemical imports for the fiscal year 1913-1914,[1] prepared by the Bureau of Foreign and Domestic Commerce in collaboration with the American Chemical Society, is ready for distribution. It appears several months later than it was promised, but in view of the world conditions in the chemical industry the publication of the census at this time is most opportune. It comprises 2500 items of import valued at $100 or more, and gives for each the quantity, declared value and country of origin. The last is stated in percentage originating in each country where two or more are concerned. Five-sixths of our imports were crude and one-sixth manufactured materials. The compilation represents the labor of a staff of 24 persons for 10 months, reviewing the records of 110 ports of entry.

The report should be carefully studied. We have endeavored to give an idea of its content by compiling a few tables which are presented herewith. Table I shows the principal countries of origin arranged in order of value of our imports from them.

TABLE 1—PRINCIPAL COUNTRIES OF ORIGIN

	Value of Imports	Percentage of Imports Crude	Mfd.	Total
England	$48,235,931	24	20	23
Germany	47,507,937	15	41	19
Chile	19,734,353	10	..	8
Brazil	17,760,918	9	..	7
Belgium	17,534,449	8	4	7
France	13,102,249	..	30	5
Canada	11,840,612	6	..	5

In Table II we list 34 items of chemicals and allied products arranged in order of value of domestic production so that an idea can be gained of the relation of imports and exports to our own production. The groupings are arbitrary, and the fact that we are exceptionally strong in one or weak in another is a matter that can be thoroughly understood only by studying the basic conditions. On the whole, up to 1914 we had not progressed far from our custom of selling our products cheap and buying dear. Compare, for example, the marketing of our phosphate with that of German potash, and the conditions affecting international exchange of material will be seen to be something more than a difference in labor costs. Our wealth in oil products is clearly shown in Table II. Had it not been for this, we probably would have had nothing to trade for German coal-tar products and would have been forced long ago to rely on our ability and ingenuity instead of trading on our natural resources.

Importance of Nitrogen Fixation

Reference to Item 5, in Table II, shows an $18,000,000 difference between imports and exports of "chemicals." This difference is almost exactly equal to the value of our imports of Chilean nitrate, which adds emphasis to the economic importance of developing synthetic nitrate processes in the United States. Again referring to Item 5, it is interesting to note that the

[1] "Chemicals and Allied Products Used in the United States." By Dr. E. R. Pickrell, Department of Commerce. Misc. Series No. 82. Sold by the Superintendent of Documents, Government Printing Office, Washington, D. C. Price, 25 cents, or New York, 734 Custom House; Boston, 1801 Custom House; Chicago, 504 Federal Bldg.; St. Louis, 402 Third National Bank Bldg.; New Orleans, 1020 Hibernia Bank Bldg.; San Francisco, 307 Custom House; Seattle, 848 Henry Bldg.; Cleveland, Chamber of Commerce; Cincinnati, Chamber of Commerce; Cincinnati, General Freight Agent, Southern Ry., 96 Ingalls Bldg.; Los Angeles, Chamber of Commerce; Philadelphia, Chamber of Commerce; Portland, Ore., Chamber of Commerce; Dayton, Dayton Chamber of Commerce.

countries of origin and their respective percentages are as follows: Chile, 37; Germany, 23; England, 13; France, 8; Italy, 5; all others, 14.

In Table III we have selected 50 out of the 2500 items and have arranged them in order of value of imports. It will be noted that 8 of them, namely, sodium nitrate, ammonium sulphate, glycerine, argols, platinum, platinum products, magnesite and sodium cyanide were imported to the value of more than $1,000,000 each.

Many of the products imported are not commercially important. Thus there are 3000 "orphans" that were imported to a value of less than $100 each. Many of these, however, are functionally important in certain of our industries and it is quite as essential to the chemical independence of this country that these materials should be produced here as it is that we should avoid dependence on Germany for about $1,000,000 worth of sodium cyanide. Imported trikresol, for example, was used by our antitoxin manufacturers before the war as a preservative for their products. It took them some time to learn that this simple tar-acid fraction could be made in their own laboratories almost as easily as distilled water and it will be very much to their discredit if they are ever again dependent on foreign sources for this material. In like manner manufacturers must take an equal interest in items that are of small financial but of great economic importance.

In studying this census the reader must remember that it represents conditions in 1914 and that great industrial changes have occurred since then. Our regular 5-yr. census of manufactures covering the year ending June 30, 1919, will indicate the domestic growth of our chemical industry. When those statistics are available, we can proceed with greater light, but in the meantime the census of imports shows very clearly the extent of our dependence and the direction in which domestic industry must expand.

A careful study of the census may reveal errors or may suggest improvements. Reasonable criticism of any nature is welcomed and should be sent to Chairman of the Import Statistics Committee, American Chemical Society, 35 East 41st St., New York City.

TABLE II—SEQUENCE OF IMPORTS, DOMESTIC PRODUCTION AND EXPORTS

	Imports	Domestic Production	Exports
Oils, mineral	$13,233,057	$362,573,653	$124,322,660
Coal-tar products	8,818,944	220,238,000	35,359
Oils, vegetable	43,467,881	192,582,100	15,913,901
Clays	1,985,006	190,688,000	3,923
Chemicals	48,278 93	173,269,000	19,859,009
Fertilizers	28,038,709	153,196,000	12,111,108
Medicinal preparations	1,289,608	150,473,000	6,788,806
Soap	788,570	106,994,620	4,941,707
Gums and resins	88,903,829	205,282	3,790,874
Paints	20,836	70,582,461	1,104,971
Oils, animal	1,033,851	51,380,313	851,142
Explosives	.....	39,645,382	2,785,633
Varnishes	64,066	36,142,256	1,038,864
Salt	423,322	34,804,683	550,380
Greases and tallows	1,726,971	29,820,000	5,049,814
Pigments	2,240,320	27,386,665	3,728,331
Oil cakes	117,104	2,191,610	21,667,672
Turpentine and rosin	28,818	21,463,890	19,882,165
Dyeing materials	995,191	20,620,000	370,676
Cosmetics	2,309,827	19,160,407	1,638,841
Baking powder	.....	17,870,674	790,274
Inks	46,821	16,859,180	625,074
Glues, gelatins	2,699,539	13,733,000	306,111
Shoe blacking, polishes	41,559	9,882,000	649,395
Abrasives	843,881	9,152,000	2,127,945
Waxes	1,923,328	8,897,106	6,622,487
Drugs	7,672,291	8,080,000	2,798,286
Tanning materials	4,228,214	7,123,971	876,257
Candles	40,004	3,696,068	283,018
Oils, essential	3,552,692	2,565,361	783,629
Asbestos	1,678,736	2,814,000	.....
Sulphur	424,909	2,676,395	2,018,923
Petrolatum	.....	1,243,388	661,889
Bronze powder	406,649	.....	.....
Total	$267,480,785	$2,017,794,065	$265,019,278

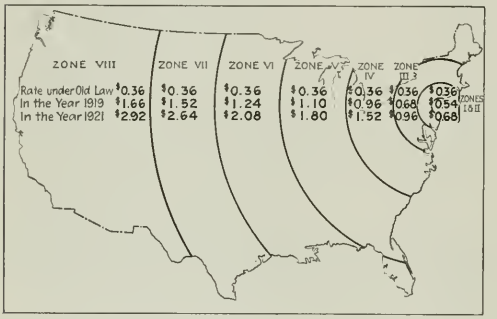
TABLE III—CHEMICAL IMPORTS IN ORDER OF VALUE

	Weight	Value
Sodium nitrate, long tons Chile, 99.5 per cent	564,061	$17,951,455
Ammonium sulphate, lb. Scotland, 46.7; England, 22.2; Germany, 19.1; Canada, 7.3; Belgium, 2.6 per cent	166,753,754	4,888,563
Glycerine, lb. France, 30.8; England, 28.7; Belgium, 7.3; Netherlands, 7; Russia, 5.4; Germany, 5.2; Spain, 4.6; Canada, 3.7 per cent	36,409,619	4,486,415
Argols, crude, lb. Italy, 46.6; France, 33.6; Portugal, 14.4; French Africa, 3.2 per cent	29,523,714	3,201,177
Platinum, fabricated, oz. Germany, 53.2; France, 29.7; England, 17.1 per cent	54,852	2,445,038
Platinum, crude, oz. Germany, 37.2; Colombia, 30.5; England, 17.4; France, 12.1 per cent	40,634	1,489,208
Magnesite, crude calcined, lb. Austria-Hungary, 92.8; Netherlands, 2.9; Greece, 2.2; Germany, 1.8 per cent	289,494,316	1,473,207
Sodium cyanide, lb. Germany, 89.9; France, 7.3; Netherlands, 1.3 per cent	8,523,867	1,243,438
Fusel oil, lb. Russia, 36.2; Germany, 18.2; England, 15.7; Austria-Hungary, 12.7; Belgium, 8.1; Ireland, 2.6 per cent	5,802,360	910,759
Casein, lb. France, 57.6; Argentina, 22.3; England, 9.6; Germany, 4.3; Canada, 2.9 per cent	10,798,614	705,264
Quinine sulphate, lb. Netherlands, 51.9; Danish East Indies, 26.7; Germany, 21.1 per cent	2,356,621	515,581
Calcium citrate, lb. Italy, 84; British West Indies, 15.6 per cent	3,097,265	493,738
Ammonium chloride, lb. England, 49.5; Germany, 48.3 per cent	9,076,729	465,429
Iodine, lb. Chile, 100 per cent	195,087	433,498
Oxalic, lb. Germany, 78.6; England, 10; Norway, 9.1 per cent	8,595,064	425,008
Sodium chloride, lb. England, 34.1; British West Indies, 28.3; Italy, 16 per cent	3,076,071	423,322
Bleaching powder, lb. England, 73.2; Germany, 21.7; France, 4.3 per cent	47,657,606	420,533
Yellow K prussiate, lb. Germany, 54; England, 27.6; France, 7.9; Netherlands, 7 per cent	3,508,225	390,050
K_2CO_3 refined, lb. Germany, 58.5; England, 16.6; Austria-Hungary, 9; France, 6.8; Turkey, 5.4 per cent	10,420,368	368,324
Sulphur, long tons Japan, 94.9; Italy, 3.8 per cent	19,398	$355,450
Thorium nitrate, lb. Germany, 99.5 per cent	147,885	337,700
Barium dioxide, lb. Germany, 45.8; England, 42; Belgium, 12.2 per cent	6,085,909	330,142
Potassium hydroxide, lb. Germany, 90.5; Austria-Hungary, 4.7; France, 2 per cent	8,395,049	320,753
Citric acid, lb. Germany, 57; England, 27.7; Italy, 12.8 per cent	652,410	304,438
Caffeine, lb. Germany, 97.7; England, 2 per cent	95,666	301,078
Potassium carbonate, crude, lb. Germany, 38.1; Russia, 19.7; Belgium, 18.1; France, 16.4; Austria-Hungary, 6.1 per cent	9,042,754	239,691
Zinc dust, lb. Germany, 74; Austria-Hungary, 20; Canada, 3.3 per cent	4,917,667	228,163
Tartaric acid, lb. Germany, 39.5; England, 19.8; Italy, 16.3; Austria-Hungary, 9.1; Netherlands, 8; France, 7.2 per cent	906,764	218,915
Mercury, lb. England, 72.5; Austria-Hungary, 11.9; Germany, 10.1; Italy, 5.4 per cent	444,896	192,768
Sodium yellow prussiate, lb. England, 71.9; Netherlands, 11.4; Belgium, 5.9; Switzerland, 4.2; Germany, 3.7 per cent	2,295,921	171,843
Palladium, oz. England, 83.8; Germany, 12.2; France, 4 per cent	3,986	169,171
Cream of tartar, lb. Germany, 100 per cent	827,746	159,972
Iridium, oz. England, 37.2; France, 34; Germany, 25.4 per cent	2,191	155,262
Ammonium nitrate, lb. Norway, 80.2; Belgium, 17.1; Denmark, 2.6 per cent	2,765,960	132,995
Santonin, lb. Germany, 100 per cent	5,239	125,360
Sodium hydrosulphite, lb. Germany, 100 per cent	505,232	116,197
Potassium nitrate, crude, lb. British India, 96.8; Germany, 3.2 per cent	3,546,580	115,344
Potassium cyanide, lb. Germany, 77.6; England, 22.3 per cent	808,721	113,199
Arsenic trioxide, lb. Germany, 33.1; Canada, 30.9; England, 23.6; Austria-Hungary, 6.3; Belgium, 6.1 per cent	3,034,070	110,168

Postal Penalty on Western Readers

THE accompanying outline map of the United States has been drawn to show the postal zones for second-class mail matter, and the cost of mailing CHEMICAL & METALLURGICAL ENGINEERING to subscribers in different parts of the country. Under the old postal law, national magazines and newspapers were mailable to any part of the country at the uniform rate of 1c. per lb. War-time legislation by Congress repealed this law and instituted a zone system under which the postage on second-class matter increases directly with the distance from the point of publication. The law did not levy the full penalty during the first year, but provided for annual increases in 1919, 1920 and 1921. The publishers of this journal absorbed the increase for the first year, but cannot continue that practice for obvious reasons.

Even a casual study of the figures is enlightening. Under the old law, annual postage on this journal cost 36c., regardless of the destination. A subscriber in



Oregon had equal privileges with one in New Jersey; but this year it will cost $1.66 to mail this journal to an Oregon subscriber for a year, and only 54c. to one in New Jersey. And that is not the full effect of the law, for in 1921 the respective costs rise to $2.92 and $0.68. It must be apparent that these costs cannot be absorbed by the publisher, considering the nominal subscription price charged. They must be passed on to the subscriber, constituting, in effect, an increased subscription price.

Congress should repeal the postal-zone law, and the reading public everywhere can bring about such action by calling the attention of Congressmen to the penalties which are to be imposed on subscribers. By way of compromise, until it can be ascertained whether Congress can be prevailed upon to repeal the law, CHEMICAL & METALLURGICAL ENGINEERING will charge extra zone postage of 50c. per annum to those subscribers living west of the Mississippi River. If the law is not repealed, it is evident that we will have to revert to the practice of half a century ago and charge all subscribers a flat price "plus the postage."

Johns Hopkins Scholarships

Through the generosity of the late Mr. William H. Graflin of Baltimore, a scholarship, to be known as the Graflin scholarship, and three assistantships have been established in the department of chemistry of the Johns Hopkins University.

The Graflin scholarship will be awarded annually to a candidate having a training equivalent to that leading to the Ph.D. degree and who therefore has had experience in research. It may be awarded twice to the same candidate. The holder of the scholarship will receive $1000 a year and will be expected to devote his entire time to research.

The three research assistantships each pay $750 a year and are open to chemists having the equivalent of a Ph.D. degree. The holder of a research assistantship will not be required to do any formal teaching, but will be given the opportunity to devote his entire time to research and to assist in the direction of research.

Applications for the year 1919-1920 should be sent to the Department of Chemistry, Johns Hopkins University, 321 Druid Hill Ave., Baltimore, before Aug. 1.

Business Training for Engineers

THE Commissioner of Education has issued a call for a public conference on business training for engineers and engineering training for students of business. This conference, national in scope and in character fully representative of all interests, will be held at the New Willard Hotel in Washington, Monday and Tuesday, June 23 and 24. All educational institutions, commercial organizations, and educational and engineering societies will be invited to co-operate. Engineers, educators and business men will be invited to discuss the following major topics: Business Training for the Engineer; Engineering Training for Commercial Enterprises; Significance of the War Experience for Engineering Education; Training of the Engineer for Overseas Engineering Projects.

The Commissioner of Education has called this conference on behalf of the Conference Committee on Commercial Engineering appointed by him, the chairman of which is Dr. Glen Levin Swiggett, specialist in commercial education of the Bureau of Education, and chairman of the Committee of Fifteen on Educational Preparation for Foreign Service. This committee is composed of administrative professors in engineering and commerce from several of the larger educational institutions and representatives from the Society for the Promotion of Engineering Education, the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Institute of Mechanical Engineers, the American Institute of Mining Engineers, and the Committee of Fifteen on Educational Preparation for Foreign Service.

Chemical Service for Latin America

The Bureau of Foreign and Domestic Commerce, Washington, D. C., is in search of a chemical engineer who has a knowledge of business and markets that will qualify him to make a survey of chemical and allied markets in Latin America. Those who consider themselves qualified to perform this service for the Government are invited to make application to the Bureau on blanks which will be furnished for that purpose. An eligible list will be prepared from these applications and examination will be given for the final selection of a proper agent. The salary will be $10 per day, with $4 allowance for subsistence. Transportation expenses will be paid. It is proposed to send the agent to Latin America July 1.

The Boston Meeting of the American Institute of Chemical Engineers will be held June 18-21, with headquarters at the Lenox Hotel. The program for this meeting was published in our last issue.

Kingsport, Tennessee, and Its Chemical Industries—I

A Brief Historical Survey of a Progressive Young American City, With a Technical Description of Its Varied Chemical Plants and Their Processes—Low Power Costs—Large Ceramic and Cement Plants

KINGSPORT is located in the northeast corner of Tennessee, in Sullivan County, on the South Fork of the Holston River, eight miles south of the Virginia line, twenty-six miles west of Bristol and the same distance north of Johnson City. The two latter cities are served by the main line of the Southern Railway, and from Bristol Kingsport may be reached by automobile in an hour and a half, or from Johnson City by an hour's travel on the Carolina, Clinchfield & Ohio Railway.

In 1910 there were on the present site of Kingsport only two farmhouses, and the population of the old town of Kingsport, two miles away from the present site, was 200. On Jan. 1, 1915, there were 900 people in the present town of Kingsport. At the beginning of 1919, four years later, a conservative estimate placed the population of the rapidly growing city at 10,000.

Numerous communities in different parts of the United States have flourished prodigiously during the war, and one might reasonably suspect, at first, that Kingsport's prosperity has been due to war's demands, and that now, with peace in sight, Kingsport will die the death. But if you ask the people at Kingsport, they will tell you that the war has held Kingsport back, and that henceforth, unhampered by the restraints on trade and commerce imposed by war-time restrictions, Kingsport will forge ahead more rapidly than before.

It was in 1915 that it was first foreseen that destiny had decreed that a city of some magnitude would be erected at Kingsport. Foresight was linked with forethought, and in that same year, with a population of less than 1000, it was decided to plan for a city of 50,000, and a professional city planner, Dr. John Nolen, of Cambridge, Mass., was engaged to lay out the design for a city on that basis. Dr. Nolen is still engaged by the city of Kingsport, and the city's growth is being guided by him.

City Divided Into Zones

Definite sites have been set aside for factories and industrial plants, and ample provision has been made for parks, playgrounds, rest-places, schools and churches, and sensible building restrictions have been adopted, applying to community sections. The city has been definitely divided into zones for manufacturing, wholesale trade, retail trade, and residences, and the benefits of the foresight exercised in this direction have already been felt.

The charter of Kingsport was drafted by the Bureau of Municipal Research of the Rockefeller Foundation. The town government consists of five councilmen, or aldermen, elected by the people at intervals of four years, and the five councilmen elect one of their number to be mayor. As it is possible that any one of the five councilmen might become mayor, a result of this system is that the people exercise more than usual care in their selection of the men who are to constitute the city council. The mayor appoints a city manager, who need not be a resident of the city or State. The latter appoints and dismisses all other employees of the city. The mayor presides at meetings of the City Council. and is the chief executive officer of the city. He also appoints the school board, two women and three men.

The School System

The school system is designed after the system of Gary, Ind., and practical education is a prominent feature. Cooking, sewing, home-nursing, fundamentals of chemistry, bookkeeping, typewriting, shorthand, manual training and agriculture are taught. There is also a play teacher for the little children, and every child is taught vocal music. Around the school-houses there are four acres of playgrounds. There is now one school building, for both graded and high schools, but two new schools have been authorized—both primary schools. In six years the school population has grown from 35 to more than 1000.

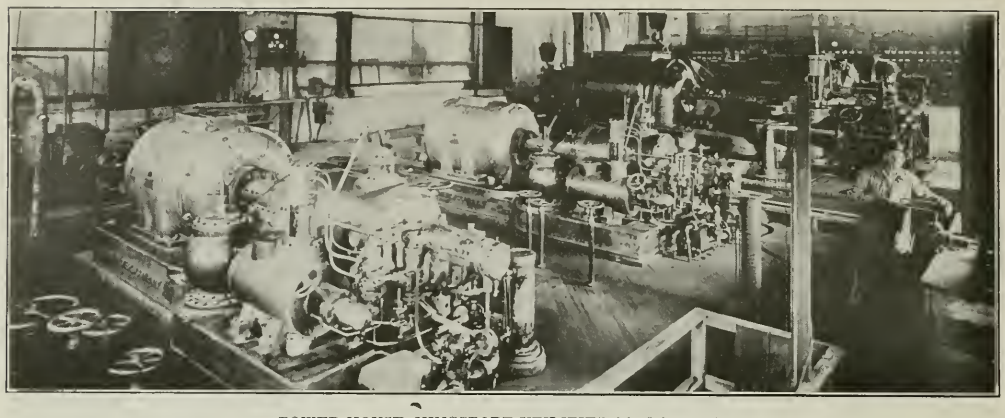
Kingsport has six churches; a modern police department; a volunteer fire department, whose members sleep in a hall with furnished rooms, provided by the city for their use; and a hospital, municipally operated, with accommodations for forty patients. There are four miles of concrete-paved streets of unusual width, built at a cost of $1.35 per sq.yd. of which the owners of abutting property pay three-fourths, and the paving of other streets with concrete is now under way, all cement, sand and stone being obtained within the city limits. The streets are flanked with wide concrete sidewalks.

A civic center has been provided, centrally located, with ample space reserved for all necessary public buildings. The planting of trees and shrubbery is being done under the direction of a trained landscape engineer, Harlan P. Kelsey, of Salem, Mass.

The Kingsport Improvement Corporation

A city could hardly have been designed and then built according to design with so much of intelligence and foresight, unless under the direction of some definite authority or power, continuous, at least thus far, in its existence. The sensible development of Kingsport is easily traced to the Kingsport Improvement Corporation, of which Blair & Co., bankers, of New York City, are the owners, with J. Fred Johnson, the chief executive of the corporation at Kingsport, as president. The Improvement Corporation owns the Kingsport Utilities Corporation (a power company to be described later) and much of the real estate in and around Kingsport. The Improvement Corporation is giving special attention to the housing of the population. The company builds houses, and either rents or sells them at cost plus a charge of $200 or $300 for the lot, giving terms to the purchaser extending over a period of four or five years. The Improvement Corporation is also interested in developing recreations for the inhabitants, and is now constructing an 18-hole golf course, under the direction of an expert from New York City.

After assigning to the Kingsport Improvement Cor-



POWER HOUSE, KINGSPORT UTILITIES CORPORATION

poration as much of the enterprise, progressiveness and determination as is its due, the fact remains that without some *raison d'être* Kingsport could not continue to thrive. Enthusiasm alone may boom a town for a while, but enthusiasm without substantial merit will not keep it booming. Kingsport has a variety of large industrial plants—a dyestuff and chemical plant, a wood alcohol plant, a cement and lime plant, a tannery and tannic acid factory, a brick plant, a wood pulp mill, a hosiery mill and a gas shell-loading plant. What induced all of these industries to locate in Kingsport within the past few years? And why, now that the war is over, does Kingsport continue to grow—on what do the people base their expectations that now progress will be more rapid than before?

Cheap Power Available

The outstanding advantage afforded to manufacturers is the opportunity for cheap power. The price of coal delivered at Kingsport for the five years preceding the outbreak of the war was $1.55 per ton. The ante-bellum price for power generated from this coal was five mills per kilowatt. Another natural advantage is the water of the Holston River. The river being fed by mountain streams, the water is unusually cold, and is useful for condensing purposes. The water is, moreover, remarkably pure—no softening is needed, and the amount of scale found in the boiler tubes is practically *nil*. Again the raw materials for making brick and cement being within the city limits, a brick plant and cement mill are already operating, and timber of many descriptions abounds in the vicinity. Building materials, therefore, are unusually cheap, and these materials are of the very best. The abundance of chestnut, oak and hemlock is responsible for the establishment of a tanning extract plant and a tannery, and the waste wood chips of the extract plant, combined with the ample supply of such woods as poplar, black and sweet gum, and maple were sufficient incentive for constructing a pulp mill. The hardwoods already mentioned, together with the beech and hickory, were the attraction for a wood-alcohol plant. All of these plants co-operate locally with one another, but the cycle of industries is not complete. Some of the resources of the Kingsport district are still undeveloped. Ten miles away there is an extensive deposit of silica, said to be 99.65 per cent pure, which is claimed to be useful for glass making. There are also in the vicinity valuable deposits of feldspar and kaolin. Other industries that Kingsport is reaching out for are a charcoal iron furnace to utilize the charcoal produced by the wood-alcohol plant; a packing house to foster the native cattle raising industry; a fertilizer plant to utilize the refuse of the tannery and the proposed packing house as well as the potash and phosphate bearing minerals of this section and also to furnish cheap fertilizer for the surrounding agricultural district; a cyanamide or lime-nitrogen plant; and a calcium carbide plant.

Kingsport Utilities, Inc.

Inasmuch as the chief attraction for industrial plants at Kingsport is the cheap power, a description of these plants may properly begin with the Kingsport Utilities, Inc., which furnishes power to all of the local plants, as well as to Gate City Quarry, 7½ miles away, over a 13,200-v. line. The corporation also lights the city of Kingsport.

Kingsport Utilities, Inc., was established in 1910. The capitalization is $500,000 common stock, $500,000 preferred, and $500,000 bonds. The original capacity was 3500 kw., which was increased in 1916 to 11,500 kw. The boiler equipment consists of four 600-hp. Edgemoor boilers, 250-lb. pressure, four 300-hp. Babcock & Wilcox boilers, and four 300-hp. Heine boilers, equipped with boiler feed pumps, feed water heaters, coal and ash handling machinery, etc.

Electrical Equipment

The electrical equipment comprises two 4000-kw. Allis-Chalmers turbo generators, 6600-v., 3-phase, 60-cycle; one 2000-kw. turbo-generator of the same make and voltage; and two 750-kw. Allis-Chalmers turbo generators, 440 v., stepped up to 6600 v. through transformers. The entire plant runs in parallel. Power is sold at "cost-plus basis." The cost of power to the various industrial plants is to-day about 1c. per kilowatt. About 4000 kw. of the total capacity is at present not utilized, but extensions now in progress at some of the industrial plants will soon absorb this surplus power. The corporation is prepared to enlarge its plant to any capacity that may be needed.

At the present time the cost of coal at the mine is $2.36 per ton, and freight to Kingsport is 58 cents. This coal comes from the Clinchfield district of Virginia. The following table gives complete information regard-

ing the analysis and fuel value of the principal coals of this region:

ANALYSIS OF CLINCHFIELD COALS

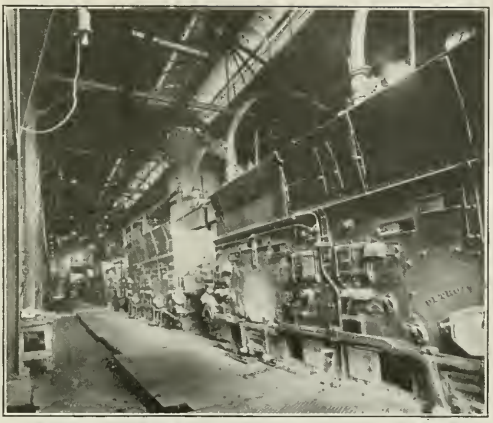
Coal Seam	Upper Banner	Lower Banner	No. 4 Seam
Proximate Analysis			
Moisture 105 deg. C.	0.95%	1.00%	0.50%
Dry Coal: volatile matter	36.95%	35.30%	32.70%
Dry Coal: fixed carbon	55.95%	57.80%	60.80%
Dry Coal: ash	7.10%	6.90%	6.50%
	100.00%	100.00%	100.00%
B.t.u. det'd.	14,560	14,660	14,580
Ultimate Analysis			
Hydrogen	5.25%	5.60%	5.10%
Carbon	80.10%	80.00%	79.80%
Nitrogen	1.55%	1.50%	1.60%
Oxygen	5.40%	5.20%	6.40%
Sulphur	0.60%	0.80%	0.60%
Ash	7.10%	6.90%	6.50%
	100.00%	100.00%	100.00%
B.t.u. calculated	14,510	14,740	14,580
By-Products			
Coke, lb. per ton	1,568	1,613	1,658
Gas, cubic feet per ton	10,000	10,000	10,000
B.t.u. per cu.ft.	600	600	600
Tar, gal. per ton	12–14	10–12	8–10
Ammonium sulphate, lb. per ton	22	20	20

The normal coal consumption of this power plant is 225-250 tons per day. The water used in the boilers comes from the South Fork of the Holston River, which flows within 100 yd. of the plant. This water is so free from scale-forming impurities that when the boilers are cleaned every ninety days, a scale of $\frac{1}{32}$ to $\frac{1}{16}$ in. in thickness is all that is found.

The Water Supply System

Kingsport Utilities, Inc., also owns the water supply system for the city of Kingsport. An impounding reservoir of forty acres, holding about 275,000,000 gal., is fed by various mountain streams. This reservoir is located $7\frac{1}{2}$ miles from Kingsport, with an elevation above the city of 590 ft. There are two reducing valves on the pipe line to the city, to reduce the pressure to 135 lb. There are 20 miles of water main (10 in. to 4 in.) in the city.

This water is piped to all of the industrial plants for fire protection and for drinking purposes. A filtering plant is now being installed, with a capacity of 1,000,000 gal. per day, and provision for an increase to 4,000,000 gallons.



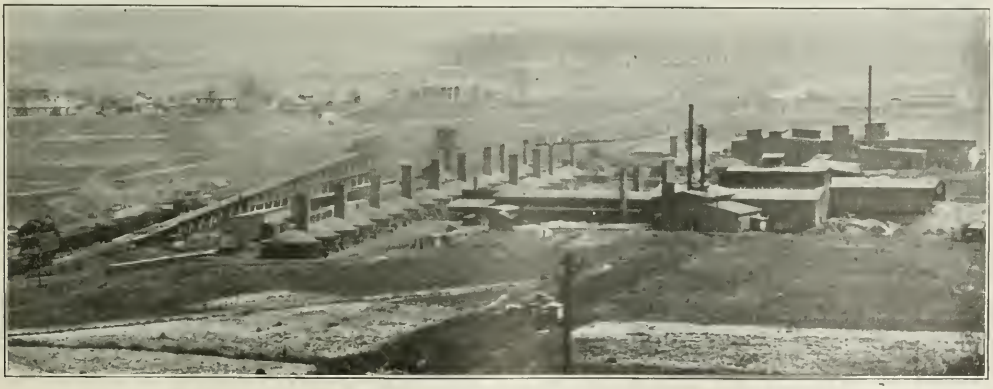
BOILER HOUSE, KINGSPORT UTILITIES CORPORATION

Kingsport Brick Corporation

The Kingsport Brick Corporation, established in 1910, was the first industrial organization to locate in Kingsport. The products of this plant are sewer pipe in all sizes from 4 in. to 24 in.; common red shale brick, face brick, "rugs," "newstiles," "textiles," radial chimney blocks, hollow building blocks, and chemical brick. The capacity of the entire plant is 150,000 bricks a day.

The plant is built near an unlimited supply of shale, the analysis of which is similar to that of the shale used by the Clinchfield Portland Cement Co., which is quoted farther on. The shale or clay is mined by steam shovel within 1000 ft. of the works, and is loaded on cars which are drawn by wire rope on a narrow gage track into the mill building. The clay is unloaded from the cars to a conveyor belt by which it is conveyed to a 9-ft. "dry pan," where the clay is ground to about 16 mesh. It is then passed through a 16-mesh screen, called a "piano wire screen," the wires running in one direction only, and the screened clay to be used for making sewer tile goes to the "wet pan," while that for making bricks goes to a pug mill. The process of making sewer tile will be described first.

In the wet pan the clay is mixed with a suitable quantity of water, and is then elevated to a belt 3 ft.



KINGSPORT BRICK CORPORATION

wide, called the slow feeder. This dumps the clay into a hopper called the fast feeder, which is handled intermittently to charge the sewer pipe press. When the slow feeder has delivered to the fast feeder a sufficient quantity of clay, an operative quickly shoves the fast feeder over, and delivers the charge of clay to the press. The sewer pipe press, manufactured by the American Clay Machinery Co., Bucyrus, Ohio, has various capacities, according to the size of the pipe being manufactured, as follows:

Capacity, in Number Lengths	Diameter of Sewer Pipe, In.	Length of Sewer Pipe, Ft.
5000	6	2.0
4000	8	2.5
3500	10	2.5
3000	12	2.5
2500	14	2.5
2000	15	2.5
1800	16	2.5
1500	18	2.5
1200	20	2.5
1000	24	2.5

In the sewer pipe press the clay is shaped into the desired size and length, and the lengths are then dried at 100 to 200 deg. F. for from four days to a week. Odd shapes of sewer pipe, such as short elbows, reducers, etc., are molded in plaster of paris molds. Sewer pipe and drain tile are burned in the kilns for five days. For 3½ days the temperature is brought up gradually, finally reaching about 2000 deg. C., and that temperature is continued for a day and a half. Salt is then added in the proportion of 150 lb. to a kiln, and firing is stopped. In some cases salt must be added twice. After 30 min. of "soaking," the kiln may be cautiously opened. It is then allowed to cool down gradually, about five or six days being allowed for the cooling processs.

For the manufacture of brick, the ground and screened clay is elevated by bucket elevator, and then is discharged into a hopper which feeds a pug mill. Here the necessary amount of water is added to give the batch the right consistency, and the damp clay then passes to the brick machine (also manufactured by the American Clay Machine Co., Bucyrus, Ohio), where the mass is molded into a long, rectangular, horizontal column, which passes on to a wire brick cutter, made by E. M. Freese & Co., Galleon, Ohio.

By means of the wires on this cutting machine the clay column is cut into individual bricks.

The bricks are dried at 300 to 400 deg. F. by loading them on push cars which are very slowly passed through a coal-fired drier. The time required for drying is 30 hr. After drying, the bricks are fired in the kilns for six days. The temperature in the kiln is brought up gradually until the atmosphere in the kiln clears. It is then assumed that the kiln has acquired a substantially uniform temperature throughout and the temperature is increased to about 1900 deg. F. No pyrometers are used in the kilns, as it is found that on account of slight variations in the clay mixtures the temperature can be better controlled by means of test pieces, or small samples of bricks. The heat is held at about 1900 deg. for 24 hr., and the kiln is then allowed to cool gradually. For chemical brick, after the usual firing is finished, everything is shut up tight, and the heat is allowed to "soak" into the brick for four hours. The ordinary building bricks manufactured by this company are said to show an absorption of only 2 per cent by weight, after immersion in water for 24 hours.

There are 29 kilns in all, each 30 ft. in inside diameter, with the walls lined with 9 in. of fire brick and a fire brick roof. The usual life of a kiln is 20 years. The capacity of one kiln is 84,000 bricks. The consumption of coal for firing is 600 to 700 lb. per thousand bricks. The company markets its products all the way from Lexington, Ky., to Jacksonville, Fla., the present selling price being $18 to $22 per thousand, according to quality.

Clinchfield Portland Cement Corporation

The raw materials used by the cement company at Kingsport are: Limestone, obtained from Gate City, Va., about eight miles distant; shale, quarried within a few hundred yards of the cement mill; and sand, obtained from the Watauga River. The following table gives typical analyses of these raw materials, as well as of the finished cement.

TYPICAL ANALYSES

	Gate City Limestone	Shale	Sand	Cement
SiO_2	1.18	58.76	81.20	22.10
Al_2O_3	0.33	22.39	10.10	6.98
Fe_2O_3	0.77	7.91	3.98	3.10
$CaCO_3$	96.46	2.84	.....	.....
$MgCO_3$	1.95	1.43	.....	.....
CaO	.....	.....	0.89	62.62
MgO	.....	.....	.....	1.66
SO_3	.....	.....	.....	1.84
Loss	.....	.....	.....	1.93

The limestone is brought from the quarries in hopper-bottom cars and is dumped over a tipple into a storage pile. From this pile it is drawn on to a conveyor belt operating in an underground tunnel, and is elevated by a bucket elevator to two Hammar mills, manufactured by the Pennsylvania Mills Co., Philadelphia, Pa. Here it is crushed to ½-in. size, and then the crushed limestone is carried back to the blending bins, each of which is provided with an automatic sampler that delivers a sample representative of the bin, as it is filled. The samples are analyzed for calcium carbonate. The blend-

CLINCHFIELD PORTLAND CEMENT CORPORATION

ing bins are in charge of the laboratory, and no limestone can be used until such use is authorized by that department. After the analysis of a sample is completed, the laboratory releases for use the blending bin corresponding to such sample, and adjusts the scale for weighing the shale, in proportion to the percentage of calcium carbonate found in the limestone. The scales used are the Richardson Automatic Scale, made by the Richardson Scale Co., New York.

The shale is quarried by hand, and rolled into the mill by hand, the cars delivering the shale to a pair of crushing rolls, from which the crushed material is carried by belt conveyor to the shale storage bins. From these it is tapped into a belt conveyor and delivered to a rotary drier, fired with coal, 5 ft. in diameter by 40 ft. long. The dried shale then goes by bucket elevator to a bin over the scales.

After the necessary adjustment of the scales, the limestone and shale are weighed, and then the two are mixed, both scales tripping at the same time, discharging the materials into a screw conveyor under the scales. This discharges the mixture of materials to a bucket elevator, which hoists it to a point over the driers. Here the material divides into two directions, and falls into two rotary steel mixture driers, 6 ft. in diameter by 60 ft. long, fired by pulverized coal, which is blown from the kiln room into the mixture driers by a blast of air, through a 4-in. pipe 160 ft. long.

The dried mixture falls into a pan conveyor and goes to the raw grinding department. Here it is carried by bucket elevator to bins above five Hammar mills, two manufactured by the Pennsylvania Mills Co., Philadelphia, and three by the Williams Patent Crusher Pulverizer Co., St. Louis, Mo. In these mills the mixture is reduced to proper fineness for the tube mills, i.e., 80 per cent must pass through a 20-mesh screen. The crushed mixture is elevated by bucket elevator and delivered to a rotary screen, and any oversize is returned to the Hammar mills. The fines pass on to the tube mill bins. The seven tube mills pulverize the screened mixture so that 97 per cent will pass through a 100-mesh screen, and deliver the product to a screw conveyor, which discharges to a bucket elevator, and this to another screw conveyor, overhead, which delivers the dried and pulverized raw mixtures to the kiln boxes, or, if desired, to a silo or storage bin for holding a reserve supply of pulverized mixture sufficient for one day's run.

Cement Kilns

The cement kilns are made of steel plate, lined with fire brick, 9 in. thick at the firing end, tapering to 4 in. at the rear end. There are five of these kilns, each 8 ft. in diameter by 125 ft. long. The pitch of the kilns is $\frac{3}{4}$ in. per ft. The speed or rotation varies from $\frac{1}{2}$ of a revolution to 1 revolution per minute. The speed is regulated by variable speed motors, operated at the firing end. The kilns are fired with pulverized coal, whose fineness is such that 96 per cent will pass through a 100-mesh screen.

The coal pulverizing equipment consists of four mills, manufactured by the Raymond Bros. Impact Pulverizer Co., Chicago, and two Ruggles-Coles driers. Each kiln is equipped with an independent blower unit, manufactured by the American Blower Co., Detroit, Mich. The amount of coal fed to the kilns is regulated by cone pulleys. From the kiln box the pulverized mixture drops into a screw conveyor, and then into a second screw conveyor below the first, for regulating the speed of delivery to the kiln. The material is fed into the kiln dry. The temperature in the kiln is about 2500 deg. F.

The clinker falls into pits beneath the kilns, is hoisted by bucket elevator and delivered to rotary coolers. There are two of these, one taking the output of two kilns and the other the output of three kilns. The coolers are old bottle-shaped kilns, 60 ft. long, varying in diameter from 4 to 7 ft. In each cooler there are four angle irons, which help to tumble the clinker about inside the revolving cooler.

From the coolers the clinker is discharged to a bucket elevator, and thence conveyed by pan conveyor to the clinker storage pile, which is exposed to the weather. This has two underground tunnels beneath it, provided with belt conveyors. The clinker is tapped through holes, at any desired point in the storage pile, and is carried back to the finishing mill.

Here there are two rotary driers, in which the clinker is dried, elevated, and dropped into a scale, which weighs 20 bbl. at a time. At the scale, $3\frac{1}{2}$ per cent of crushed gypsum is introduced. The scale dumps into a pit, from which the dried clinker is elevated by bucket elevator to an overhead pan conveyor, delivering to the Griffin mill boxes.

There are ten Giant Griffin mills (40 in.) made by the Bradley Pulverizer Co., Allentown, Pa. In these the dried clinker is ground so that 100 per cent will go through a 20-mesh screen. The ground material then goes through four Allis-Chalmers tube mills, where it is pulverized to standard specifications, which are, usually, that 80 per cent must pass through a 200-mesh screen. The pulverized cement is elevated to a screw conveyor, which carries it to 24 bins, 12 in each of two stock houses, the capacity of each bin being 4000 bbl. In the stock houses the cement is drawn from the bins into screw conveyors running transversely, and delivering into a central conveyor which feeds the six Bates automatic packing machines, manufactured by the Western Valve Bag Co. of Chicago. After packing in bags, the cement is trucked to cars for shipment. The capacity of the plant, running 24 hr. per day, 12 hr. per shift, is 2500 bbl. of cement daily.

Cottrell Precipitator

The Clinchfield Portland Cement Corporation has just completed the installation of a complete Cottrell precipitating plant, comprising both a dry treater and a wet treater, for precipitating the dust from the cement kilns, with the twofold object of recovering potash and eliminating a nuisance. A steel flue 9 ft. wide by 14 ft. deep, provided with hopper bottoms and screw conveyor beneath, conveys the gases from the kiln to the dry treater. This flue, and also the stacks which permit the gases to escape into the atmosphere, are provided with dampers, so that the gases may either be allowed to escape or be diverted to the treater at will. A small quantity of dust low in potash may be precipitated in the flue. The flue is 102 ft. long, and on the top of it, to utilize some of the waste heat, there are evaporating pans 9 ft. by 9 ft. by 6 in. deep in the center, for evaporating the solution returned from the wet treater. By means of the screw conveyor underneath the flue, the dust can be returned to the kiln, in case the price of potash should not warrant putting the dust on the market. The portion of the flue nearest the dry treater is provided with a water spray inside, to humidify the gas.

The dry treater, built of steel and brick, consists of four chambers, two on either side of a central combination inlet and outlet flue. This flue in its entirety is rectangular in shape, with a diagonal steel partition extending from the bottom of the inlet end to the top of the outlet end. The top part, above the partition, is the inlet flue, and the bottom part, below the partition, is the outlet flue. The ports for letting the gas into and out of the four treating chambers are provided with dampers. In each chamber the gases pass down through eighty 12-in. iron pipes, each 15 ft. long. In the center of each pipe, from top to bottom, hangs a soft annealed iron wire, No. 14, B. & S. gage, with an iron weight, shaped like the frustum of a cone, weighing about 9 lb., suspended at the bottom. To keep the wires from swinging, and to keep them spaced properly, the wires pass through an iron grid, placed 15 in. below the bottom

COTTRELL PRECIPITATOR AT CEMENT PLANT

of the 12-in. pipes and just above the 9-lb. weights. This grid is made of flat iron strips, 1 in. wide by $\frac{3}{16}$ in. thick. The grid is stiffened at two diagonally opposite corners, by omitting the usual wire from the 12-in. pipes at these corners, passing through each of these two pipes, instead of the wire, a 1¼-in. iron pipe which is firmly fastened at the top, and also to the grid at the bottom.

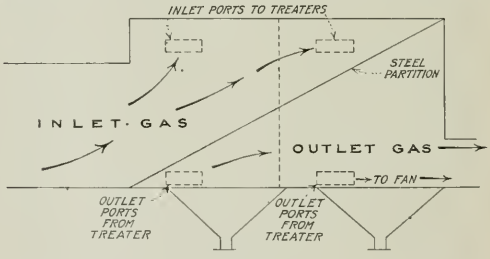
The current is transmitted by means of a ⅜-in. iron pipe connecting with a bus bar made of 5-in. iron pipe. This connects to the various iron wires suspended in the 12-in. pipes. The bus bars are insulated by means of Alberene stone slabs, made at Schuyler, Va. The insulators consist of eleven slabs, six of which are 6 in. by 6 in. by 1 in. thick, and the five others 9 in. by 9 in. by 1 in. thick.

The four treaters discharge the gases into a common outlet flue, which leads to a Buffalo Forge Co. conoidal multiblade fan, with impeller 12 ft. in diameter and speed of 144 r.p.m., and said to be capable of discharging 180,000 cu.ft. of gas per minute.

The dry treater will precipitate only the coarser dust. The very fine dust and the fume will be blown by the fan to the wet treater. The temperature of the gas in the dry treater ranges from 900 to 1100 deg. F. The capacity is 20 tons of dust per day, which is expected to contain about 10 per cent of water-soluble potash (K_2O). The treater will operate continuously, but the dust will be withdrawn from the hopper-bottoms only at intervals, and will be packed for shipment without further treatment. This equipment has already been tested experimentally, and undoubtedly by this time it is in continuous operation.

The wet treater, like the dry treater, has four chambers, but here the chambers are arranged in a single row, with the inlet flue passing along one end of the four chambers. The gas is blown into this flue by the large fan mentioned above, and is admitted to the treater chamber through dampers of the "jug" type, two dampers being provided for each chamber. The gas passes upwardly through the damper openings (about 36 in. in diameter) then turns at right angles to the left and passes into the chamber, which is provided with six vertical concrete partition walls, each 6 in. thick by 10 ft. wide by 14 ft. high, built 15 in. apart. These walls divide the chamber into seven compartments, and in each compartment there are suspended, between the walls, 24 iron wires, No. 14 gage, weighted at the bottom with 30-lb. weights, and connected to one another at the bottom by a grid made of 1¼-in. iron pipe. There are 168 of these wires in all in each chamber. The surfaces of all the walls are covered with flowing water, which is distributed at the top by means of a system of pipes. The gases, after turning to the left, pass through the seven compartments, the fine dust and fume are precipitated by the high tension current with which the 168 wires are charged against the wet walls, and are washed by the flowing water to the bottom, and the gas passes on to the left end of the compartments, and escapes through a damper hole to an outlet flue which connects with all four of the chambers, and leads to a concrete exit stack, 8 ft. in diameter by 18 ft. high.

Power for the treaters is obtained from the Kingsport Utilities Corporation at 440 v., and by means of four motor generators it is changed to 220 v., a.c. single



DRY TREATER

phase, and is then stepped up by transformer to 75,000 v.

The precipitated liquid and dust are collected in a tunnel beneath the treater chambers, and flow to a concrete settling tank 24 ft. in diameter by 12 ft. deep at the deepest part, the bottom being funnel-shaped. The liquid is pumped to the evaporating pans previously described, on top of the gas flue, and is there evaporated. The sludge from the settling tank is filter-pressed, and the cake rejected. The filtrate returns to the settling tank, and is pumped along with the other liquid to the evaporating pans on the flue. The evaporation is not carried to dryness, but at a definite specific gravity the liquid is drawn off into two final evaporating pans 16 ft. long by 8 ft. wide by 3 in. deep, fired with coal, where the evaporation is completed and solid crude potash obtained. The Cottrell plant, as well as the cement mill, was designed and built by Richard K. Meade & Co., Baltimore, Md.

The Clinchfield Portland Cement Corporation also owns and operates a lime-burning plant, located a short distance from the cement mill. It consists of five vertical kilns, built by Richard K. Meade & Co.

Flotation for the Practical Mill Man

A Description of Several Important Factors in Concentration by Flotation — Extraction and Grade of Concentrate — Slime Effects — Pure Water — Time — Oils — Pulp Density — Recleaning Concentrates

By FREDERICK G. MOSES

IT IS a well known fact that the difficulties encountered in flotation plants in different sections of the country are many and varied. While it is true that, in the great majority of mills, the troubles are soon located and remedied, there are many other plants which are not so fortunate in the solution of their problems. It is usually found in the latter case that, although there is nothing apparently wrong with the mill or its operation, the results being obtained are not so good as the experimental work on the ore had led the builders to believe could be obtained. Because a profit is being made, the idea of leaving well enough alone often leads the operators into the state of mind in which they are satisfied to make the best of a bad situation and to be content with the results that they can get.

There are some cases in which the mill results are not satisfactory and, moreover, cannot be readily improved. This is, however, seldom the case. More often the poor results are caused by some condition, often a simple one, that can easily be remedied, if located. Unfortunately, there is such a multiplicity of conditions, any one of which can cause poor flotation results, that it is hopeless for the average mill operator to investigate more than a comparatively few possibilities.

It will be the object of this discussion to suggest some of the factors affecting flotation results, and to suggest ways in which some of them may be overcome. Of course, it will be possible to consider only a limited number of the conditions that work for poor flotation results. There is always the chance, however, that a discussion of some of the more common difficulties encountered in flotation plants will suggest the manner by which some specific or unusual source of trouble can be discovered and eliminated.

Flotation a Concentration Process

It is imperative that the fact that flotation is a concentration process, as much as any gravity scheme, be borne in mind. If this fact is remembered when considering any phase of flotation, the solution of the problems connected with its operation will be considerably simplified.

As flotation is a concentration process, it must follow that the economic laws of concentration will apply to it as much as to the gravity concentrator. In every case of concentration there is a maximum extraction and grade of concentrate possible. This theoretical result can be approached in the commercial installation, but never reached. Usually the greatest obstructions in the way of obtaining scientific results are the economical considerations that surround the mill operator on all sides. The plant must be run to make the greatest profits, and attempts to obtain better metallurgical results will often serve only to reduce the profits.

It must also be borne in mind that, like a table, the capacity of a flotation machine is limited. Notwithstanding the fact that the maximum capacity is but seldom reached, there is always the possibility that this be done, to the detriment of the results obtained on the machines. If the operator takes care that the apparatus is not overloaded, he has eliminated many of the chances for poor work in his plant.

The crushing of flotation feed is as important to good flotation results as the crushing of table feed is important to good table work. The sizes that can be floated are limited to a fewer number than can be tabled successfully, and poor sizing or classification of flotation feed can cause even more unsatisfactory results than in gravity machines. The ore must, of necessity, be crushed fine enough to free the maximum quantity of mineral, but with the production of the minimum amount of slime or very fine material. The slimes, especially the true colloidal material, will be found to be more often the cause of poor flotation than any other factor that will be encountered in the plant.

Extraction and Grade of Concentrate

The metallurgical and economical success of the flotation plant depends on the recovery of the greatest amount of the valuable mineral from the ore in the purest possible concentrate. Just what are the economical limits of extraction and grade of concentrates depends on local conditions and must be determined for each mill; in the present discussion, they will be considered to be the best metallurgical results allowable under the conditions existing in the locality of the mill.

As already suggested, each ore has a maximum and definite ratio of concentration, and hence there is a maximum grade of concentrate possible. The maximum extraction is, of course, 100 per cent of the values in the ore, a figure that can only be approached. The important fact to be remembered in this connection is that in the flotation plant, as in the gravity mill, recovery can be increased only at the expense of grade of concentrate, and vice versa. The flotation operators who remember this fact will save themselves much trouble and worry that always follow attempts made to obtain scientifically impossible results. Unfortunately, so few plants are approaching theoretical results that their consideration can be eliminated from the present discussion.

Flotation Recoveries

Ignoring, for the present, the consideration of grade of concentrate, it can be said that extraction by flotation depends on many factors, among the most important of which are: (1) The physical condition of the ore being treated, (2) the flow sheet of the mill, and (3) the effectiveness of the flotation operation. While the first two are not so important as the last, they are so often the cause of flotation difficulties that they should be considered.

At the present time, the mineral values that occur in

the ore as sulphides are all that can be depended upon to be recovered by flotation. When only non-oxidized sulphides are present, it should be possible, theoretically, to obtain high metallic extractions. However, when such easily oxidized material as iron sulphide is present and carries values, as often happens, trouble in obtaining good recoveries may be encountered. There have been put on record cases in which this material, by simply lying in the ore bins for a short time, has undergone enough oxidization to make the flotation of the iron sulphides very difficult. The remedy, of course, for a condition of this sort is to mill the material as soon as possible after it has been hoisted.

The size of the sulphide particles occurring in the ore greatly affects the possible recovery from an ore. When this sulphide reaches the flotation machines in very coarse sizes it will not float. Unfortunately, on the other hand, when the sulphide particles have been ground too fine, or "slimed," they can be floated only with difficulty. In most cases it will be found that the greatest loss in the tailings from a flotation plant is in the minus 200-mesh material. Proper crushing previous to flotation will correct these conditions to a great extent. However, the actual size and condition of the sulphide, as it occurs in the ore, will be a very dominant factor.

All ores carrying decomposed or kaolinized minerals are difficult to float. This physical condition will probably have more effect on the actual flotation operation and its results than any other single thing that could be mentioned, and at the same time it is the most difficult to overcome. Why clay and other colloidal material have such harmful effects is difficult, at best, to explain on a scientific basis. A discussion of this point will delve so deeply into the pure theory of flotation as to be out of place in this consideration. Instead, a few suggestions about means of eliminating or controlling this material will be more to the point.

There may be said to be two general schemes by which the detrimental effect of slime may be overcome. The first and most important is by flocculation or precipitation by chemical or electrochemical schemes. The second and least used method is that of washing. Heating of the ore before crushing is sometimes tried.

Rather than give a long scientific definition of just what colloidal material is, it will be better to give a very simple method of determining the presence and amount of this material. Colloidal material, or more commonly "slime," can be best detected and its quantity estimated by the slowness with which it will settle in water. A rough application of this scheme can be made by taking a portion of the flotation pulp and shaking it thoroughly in a bottle. If there is any quantity of colloids or slime present the water will remain murky after standing for a few minutes. If this cloudy appearance persists for half an hour there is probably sufficient slime present in the pulp to interfere with flotation.

The amount of the slime that may be present may be roughly estimated by the depth of clear water that appears on top of the pulp in a given time. Of course, this means will only give comparative results, but this is all that would be required except in special cases.

Removal of Slime

Some simple chemical compounds, under certain definite but usually little understood conditions, have the property of causing the suspended or deflocculated slime in the pulp to collect together, or flocculate, changing the physical conditions in such a way that rapid settling occurs. It has been found by experiment that slime in this condition usually has very much less harmful effects on flotation than when deflocculated. Sulphuric acid, lime sodium carbonate, acid sodium sulphate, copper sulphate and many other substances, when used in very small amounts, have the property, under certain conditions, of flocculating the slimes. In this way their harmful effects are very largely removed.

At the present stage of our knowledge of this phase of flotation, it is practically impossible to foretell which of the numerous reagents that have been used for this purpose will give the required results on a particular ore. The most effective one can only be determined by experiment under the conditions under which it is to be used. The reason for this is our lack of knowledge of the real manner in which they act on the slimes in the ore.

The ideal manner of ascertaining the reagent to be used is by direct experimentation in the commercial cells of the operating plant. If, for any reason, this is not feasible, indicative results can sometimes be obtained by a series of tests made in bottles. Several samples of the pulp from the flotation machines, containing the oils being used, are placed in a series of bottles and well shaken. Two or three drops from solutions of the various reagents are then added to the bottles, a separate bottle being used for testing any one solution. The bottles are then placed where they will be free from vibration for an hour or more. It will be seen, at the end of this period, that some of the bottles have a certain volume of clear water above the cloudy pulp and that, in certain cases, this volume will vary widely. It is usually the case that the reagent showing the greatest settling effect will produce the best results when used in the cells. However, this is not always the case.

The removal of slimes or colloids by washing is a more difficult matter, requiring quite an installation of settling tanks or thickeners, and a comparatively large supply of fresh, pure water. This last item is of the utmost importance. The actual operation of the scheme is quite simple. The pulp, before being floated, is settled in the thickening tanks, which are so operated as to give the thickest spigot product possible, without allowing the overflow to carry away an excessive amount of valuable mineral. The overflow, which carries a large portion of the slime material, is allowed to run to waste, and the thick spigot product is diluted with sufficient clean, fresh water to give the correct pulp density for flotation. This method has worked well in several large plants in the West.

Another scheme which might be used, but which for various practical and economical drawbacks has received but scant attention, involves heating the ore before crushing to a temperature great enough to put the slime-forming material in the ore into such a physical condition that slime formation is retarded when the ore is wetted and crushed.

There are many materials foreign to the ore, such as decomposed vegetable matter, lubricating oils from line shafts or crusher bearings, soap, sewage, grease from mine-car wheels, etc., that will interfere greatly with flotation. The only sensible remedy for this type of trouble is to eliminate the source of it. Great care must be taken to prevent these substances from getting into the flotation feed. The great difficulty often encountered

in finding the source of this sort of interference makes it imperative that care be used to eliminate it.

Mill Flowsheets and Their Effects

Sometimes it does not seem possible that such a simple matter as the location of a table in a flotation mill could make any great difference in the results obtained. Nevertheless this has often been proved to be the case.

It is as necessary that the flowsheet of a plant using flotation be as carefully worked out by experiment as when gravity processes only are to be used. Many flotation plants can be shown to be doing unsatisfactory work for this reason alone.

In many instances, the ore should be tabled previous to flotation in order to remove the heavy sulphides which are present but which cannot be floated. These will only tend to build up in the machines, choking up the cells and preventing their efficient operation. Also, it is sometimes possible so to remove from the pulp certain deleterious substances, such as slimes.

In certain cases the best results demand that the pulp be tabled after flotation. A great tendency in many flotation plants is to carry too dilute pulp in the flotation apparatus. Tabling before flotation is bound to add water to the flotation feed and this causes poor operation. Tabling following flotation has not this drawback.

The use of pilots by which the work of the flotation machines can be judged should not be overlooked in this connection. The flotation operators can soon be taught from the appearance of the tables treating the flotation tailings whether the cells are doing good, bad or indifferent work. They thus have an optical demonstration of what their part of the general scheme is accomplishing, and this will always work toward securing better results from the flotation machines.

Before leaving the discussion of mill flowsheets and their bearing on flotation results, the effects of various types of crushing on flotation results should be mentioned. This is one of the things that is without the pale of help from the operator, but some valuable suggestions may be evidenced by the consideration.

There is no doubt that the type of crushing to which the ore has been subjected before flotation will have a noticeable effect on the results obtained. The well-known case of the Inspiration mill, where a better result was obtained by crushing with iron on iron than by pebbles on iron, is an example of what a difference such a simple point can make.

The fact that the type of crushing which produces a large amount of slime is not as satisfactory as that which will produce the minimum quantity has been already suggested. A certain plant in Arizona is divided into two units, exactly alike, except for different types of crushing machines employed in them. The ore, flotation equipment and other factors are the same. The extractions obtained in the two units always varied to a certain extent, and the difference in the crushing was the only explanation that could be offered as the reason for this peculiar behavior.

Flotation has a definite field in saving that portion of the sulphide content of an ore that is too fine for satisfactory gravity work. It can never be made to replace tables satisfactorily, except under an unusual combination of circumstances. Stage crushing, therefore, with the removal of the mineral as soon as it is freed, followed by flotation of the sulphides that have been crushed too finely for table work, in general seems to be the best and most logical scheme, and should be followed whenever possible.

Effectiveness of Flotation Operation

The points already discussed have been mentioned because of their indirect effect on flotation. There are, also, certain factors in the operation of the flotation equipment itself that are of even more importance to good flotation results than those already mentioned.

One of the most important factors in good flotation is the oils or combination of oils that are being used. If all of the other conditions are perfect with the exception of the oil, good flotation results are impossible. Unfortunately, the investigation of oils covers such a large field and depends on so many little understood or unknown factors, that no definite rules for determining the most satisfactory oil can be given.

As long as the art of flotation has been practiced, the only feasible method of determining the oil best adapted for an ore has been by laboratory or mill experiments. This method of investigation involves much time, patience and money, but the importance of the information gained always justifies the expenditure. The operator should never reach the state of mind that permits him to be satisfied with the oil he is employing. He should test all of the logical mixtures available, and as new oils come on the market, they should, also, be given their chance.

The agitation to which the oil and pulp have been subjected is the next important factor in good flotation results. This must be correct, both with regard to kind and amount. The lack of sufficient agitation is usually evident at once, but too much is more difficult to recognize and is just as harmful as the opposite state of affairs.

Too much agitation will do one of two things: either produce too much froth, usually of an unsatisfactory character, or cause the oils to be so thoroughly emulsified as to destroy much of their flotation value. It is very probable that the principal function of much of the acid used in flotation is to throw oils out of emulsion that have received too much agitation in the ore pulp.

If the mechanical agitator type of machine is not designed correctly for the ore which it is to treat, it will either produce too much froth or too little. Either of these conditions will tend to cause poor recovery. When the ratio of the size of the agitator and its speed is correct, or that of the agitator compartment to the froth tank or spitzkasten, the quantity of froth produced by the use of the right amount of oil will be wrong. In such a case, the common method of attempting to rectify conditions is by changing the amount of oil used. This is unsatisfactory in most cases.

If too little froth is being made by the machine by the use of the correct amount of oil, air blown into the pulp at the bottom of the spitzkasten will often correct matters very satisfactorily.

The troubles caused by the production of too much froth when the correct amount of oil is being used are much more difficult to rectify. The greatest chance for improvement, under these conditions, is to increase the tonnage to the machine, although other factors may cause this scheme to fail.

Over-oiling the flotation pulp will usually be indicated by the occurrence of large amounts of mineral-bearing

froth in the launders carrying the tailings from the machines, or on the tables or other apparatus that may be used to re-treat the flotation tailings.

Importance of Pure Water

One of the greatest necessities for good flotation work is a large and constant supply of fresh and pure water. It is considered good flotation practice to settle the water from the flotation tailings for re-use in the flotation circuit, in order to obtain the benefit of the oils that will be returned to the mill in this manner. This is logical and works very well, within certain limits. A point that must at the same time be considered is that the soluble constituents of the ore or oils will gradually be concentrated in this return water, and will eventually attain an accumulation that will interfere very materially with the operation of the flotation machines. For this reason, increasing the amount of fresh water that is being added to the flotation circuit will often work wonders in the way of improving flotation results. This fact is very easily determined and the test should be made at frequent and regular intervals.

Often the fresh water supply of the mill will carry certain unsuspected impurities in solution. These impurities may be either harmful or beneficial. The preponderance of chances are, however, that they will interfere with the proper operation of the cells. Fortunately, most of the inorganic salts that occur in this way can be very easily and cheaply removed by simple chemical precipitation. Many cases have been known where the flotation plant had been built on the strength of a large amount of successful experimental work, but no successful results could be obtained until by chemical analysis of the water used in the mill circuits the presence of large amounts of inorganic salts in solution had been demonstrated. When this material had been removed by the use of lime or some other necessary reagent the mill at once commenced to produce the results that had been expected when the plant was completed.

Organic material, such as soaps, glues, decomposed vegetable matter, organic soil constituents, etc., will cause more harm in the flotation plant than the inorganic salts just mentioned. Their removal is a much more difficult proposition. If their presence can be proved to be the cause of trouble, it would be better to employ special talent to handle the situation rather than to allow inexperienced men to try their hand.

Time Factor and Flotation Results

The period of time during which the ore pulp is under treatment in a flotation machine is a most important factor of good flotation results. Flotation is by no means an instantaneous process. A certain definite time is required to remove the concentrate from the ore pulp. The amount of time required for this purpose depends on several important considerations, among which may be mentioned (1) the amount of pulp, in gallons, which is being treated in the flotation apparatus per minute, (2) the solid content of the pulp volume being treated, (3) the number of pounds of concentrate that must be removed from each gallon of the pulp, (4) the strength or carrying power of the froth being made on the machine, and (5) the quantity of froth being made per unit time.

It will be evident that, other things being equal, the more dilute the pulp the greater will be the velocity with which each unit of ore in the pulp will pass through the machine. Hence, to obtain the same time of treatment on the more dilute pulp will require a greater comparative length of time of treatment in the machine. When dealing with pulp dilution, however, many other factors enter into consideration and the above can only be taken as a generality.

On the other hand, a pulp must not be too dense, or the bubbles cannot rise freely to the surface. When the pulp is too dense there is the added chance that the bubbles will be scoured clean of their mineral load. The correct pulp density to fit the conditions of the case can only be determined definitely under practical operating conditions.

A froth has a certain maximum carrying power. When it is made at a definite rate per minute it can lift only a certain limited amount of concentrate. If more pounds of concentrate are contained in the pulp fed to the machine than can be removed by this froth, poor extraction of the sulphide in the ore is bound to result. When the poor recovery in the flotation machines can be definitely laid to this condition, the remedy is either to feed a smaller volume of pulp to the apparatus, to make more froth of the same character or, by means of different oils, to increase the carrying power of the froth being produced. The most satisfactory method of remedying the difficulty must depend on the ore and the other local conditions existing in the plant. These points are all matters of experiment and skill of operation.

Relation of Grade of Concentrate to Extraction

In all ore-dressing and concentration processes, the grade of concentrate produced has a most important relation to the possible extraction. A few of the more important reasons why this is especially true in flotation will be mentioned.

An observation of the froth forming on the top of the pulp in a flotation machine will clearly show that a great deal of the concentration that takes place in the machines takes place in the froth. The froth nearest to the pulp will be practically the color of the pulp, but the closer the top the froth is observed, the more nearly its color approaches that of the pure mineral that is being floated.

This effect is caused by a mechanical action that goes on within the body of the froth itself. The bubbles seem to have only a comparatively weak selective action on the sulphides in the pulp itself. This condition causes the froth, first released at the bottom of the froth column, to carry a very large amount of gangue material. As soon as the froth is out of the water, however, it commences to break up, the bubbles first formed breaking up to re-form a slightly fewer number of new bubbles. During this process of re-formation, the sulphides are caught on the newer bubbles formed, while the gangue is, to a large extent, forced to drop back into the pulp owing to the decreased froth surface. This action goes on from the bottom to the top of the froth column, causing the froth the greatest distance from the pulp itself to be the highest in grade.

It can be seen from this that the deeper the froth column carried on top of the pulp in the flotation machine, the higher is the grade of concentrates produced and the greater is the amount of gangue dropped from the froth into the pulp, at the same time, however, the greater is the chance for the sulphide particles to be

dropped into the pulp and lost in the tailings, causing a lowered extraction.

This shows the reason for the relation between the grade of concentrate produced and the extraction possible, and, also, the principal reason for the use of one set of machines for producing the best tailing possible, and the use of another set of apparatus for recleaning the froth produced on the first machines.

Producing Clean Concentrates

At the first of this discussion, the fact was mentioned that, in order for a plant to be successful from both a metallurgic and an economic standpoint, a good extraction of the values in the ore must be obtained, and a high grade concentrate must be produced.

The concentrate is the material that must be sold to produce the income from the milling operation. The greater the amount of valuable metal present, the more can be obtained for it, while the smaller the amount of impurities present, the fewer the penalties imposed by the buyer and the less charged for their treatment. All these considerations make it imperative to produce the highest grade concentrate economically possible.

The grade of flotation concentrates produced will depend on several factors, among which can be mentioned (1) the natural amenability of the ore to the process, (2) the simplicity of the sulphide content of the ore being treated, (3) the sort of results that the flotation equipment is being operated to obtain, and (4) the skill and care with which cleaning the concentrates is done.

The first two of these factors are, to a great extent, beyond the control of the operators. However, the second two are of such a nature that they can be much influenced and controlled by the operators.

Natural Amenability of Ore to Flotation

It has been often found that two ores, apparently of the same physical and chemical makeup, respond very differently to flotation, the one giving maximum results without trouble, while the other can only be treated satisfactorily with the greatest difficulty. Just why this is true is often very difficult to explain.

It is, however, usually easy to obtain both high grade concentrates and high extractions when treating the ores that respond easily to flotation, the probable reason being that when dealing with this type of ores, a small amount of the lighter oils will give high recoveries of the sulphides present, and, at the same time, this type of oiling will in nearly all cases produce the richest concentrates.

When dealing with the other ores—those which can only be made to respond to flotation treatment with difficulty—it is usually necessary, in order to obtain high recoveries of the sulphides, to use a comparatively large amount of heavy flotation oils. This class of oils will, it is true, make high recoveries, but in so doing often float such large amounts of gangue as always to cause the concentrate to be low grade.

As suggested, these factors usually depend more on the ore itself than on any of the conditions that can be controlled. However, from the above it can be seen that when the ore is readily amenable to flotation, both high recoveries and rich concentrates can be produced by the same operation, but when the ore does not respond readily, high recoveries can be obtained with greater ease than high grade concentrates, and neither can be gotten at the same time.

In an ore composed of simple gangue minerals and only one floatable mineral, it is easy to see that the chance of producing high grade concentrate is greater than when two or more minerals that float are present.

Complexity of Sulphides and Grade

When several sulphides, such as lead, zinc and iron sulphide, for instance, are present in the ore, there are two possible schemes that might be used in overcoming the tendency for the production of, say, a low grade zinc concentrate. The success of either of these will depend largely on the character of the ore and its sulphide constituents. One of these methods involves the removal of one or more of the sulphides by gravity before the flotation of the ore for the recovery of the other sulphide. The other scheme depends on a differential or selective flotation operation to recover one of the sulphides without removing the other two. This has been done to a limited extent in various sections of the country, but at best it is a very delicate operation and will require large amounts of experimental work, careful control of the flotation operations themselves, knowledge of the relations of the various minerals to one another and, above all, great skill in the actual operation of the equipment.

There is no question that the grade of the flotation concentrates can be influenced greatly by some such schemes as those mentioned, but their success is bound to be limited. They are really special cases of flotation and should not be discussed here.

Flotation Operation and Grade of Concentrates

Probably the greatest factor affecting the grade of the product is the manner in which the machines themselves are run from shift to shift. The grade of the concentrates will depend largely on (1) whether the machines are being operated to obtain the maximum recovery or the maximum grade of product, (2) on the skill and intelligence with which the oils are used, (3) on the skill and care with which the pulp level and depth of froth on the machines are controlled, and (4) on the pulp density.

The effect of the first point mentioned, the results that are being striven for on the machines, has been suggested already. Much of the concentration takes place in the froth column, and when the froth is allowed to discharge from the apparatus so slowly that most of the gangue has had time to drop from it, some of the mineral will also be dropped into the cells, causing a lowering in the recovery, but at the same time the maximum grade of product will result. Just the point at which these two conditions should be balanced is an economic matter and can only be worked out on the profit sheet of the mill.

The fact should be emphasized at this point that beyond a certain point the grade of concentrate can only be better at the expense of recovery, and vice versa. This will be the dominating thought that will be carried through any discussion involving extractions and grade of concentrates by flotation processes, or any other process, for that matter.

Oil and Grade of Concentrates

The necessity for the intelligent use of flotation oils and reagents to obtain the highest grade of product from a flotation machine has also been suggested in another connection, and should be fairly evident. The strength and carrying power of the froth will depend

largely on the kind and amount of oil used in the circuit. The grade of the concentrate also depends very largely on the same factors. If a weak froth can be made which will carry sufficient sulphide to give a high recovery, this froth, from its very nature, will not be prone to carry much of the gangue.

If a froth of a strong, stiff character is required to give high extractions, it will tend to carry much more gangue material and hence produce a lower grade of concentrate. As the oils are the dominating factor on which the strength and carrying power of the froth depend, the evident relation of the oils to the mineral purity of the concentrate should be clear.

Of course, the ideal practical condition will be to use the oil mixture that will prevent the flotation of the gangue to the greatest extent, and yet float all of the sulphides present in the machine. Under this condition the highest recovery will be possible, and the concentrate produced will be ideal for cleaning in the cleaner cells.

Pulp Level or Depth of Froth

The relation of the level of the pulp and the depth of froth to the grade of the concentrates was suggested in connection with the remarks on extraction. Slowly discharging froth and deep pulp level mean a long period of time for the concentration in the froth column to take place, with the dropping out of a correspondingly large amount of impurities from the froth.

The operators can soon learn, under the different conditions that will be encountered, the correct depth of pulp to obtain the highest extraction and, at the same time, the maximum grade of concentrates. The pulp level will depend to a certain extent also on the quality of sulphides in the pulp fed to the machine.

As a general rule, the larger the amount of sulphide that must be removed from the machine, the higher the pulp level will be carried, and the faster the froth will be discharged. The operators soon learn to judge these conditions, and make the necessary adjustments when they are required.

Pulp Density and Grade of Concentrates

The reasons for the variations in the pulp density upon the grade of concentrates are a little more difficult to understand. The ratio water to solid in a flotation machine has much to do with the character of the froth the machine is producing. Just why this should be true is hard to say.

It has been previously shown that the character of the froth affects the grade of concentrate. Now froth characteristics will continue to have the same effect on the purity of the concentrate, regardless of whether they can be traced to under- or over-oiling of the pulp, or by thickening or diluting it, as in the case now under discussion.

There is yet another manner in which the pulp density may affect the purity of the concentrate. It is the effect of the pulp density on the amount of sulphide that will be carried into the machine in a certain time.

A flotation machine can produce a given amount of froth of certain characteristics in a given period of time. If a dilute pulp is being fed to the machine, there will be fewer pounds of sulphide to be removed by this amount of froth; a condition that, due to its unsaturated condition, will increase the chances of the froth picking up the gangue material, and therefore lowering the purity of the concentrates.

As would be expected, increasing the pulp density will tend to have the opposite effect on the grade of concentrates. In this case, there is an increase in the amount of mineral to be floated by the available froth, causing it to become quickly saturated with sulphide and so leaving but little space for the gangue material. This result is probably brought about by the fact that the sulphides are the easiest to float and will have the greatest tendency to be attracted to the froth and held there, in preference to the non-sulphide material. This condition in the machine will also tend to increase the concentrate grade, but at the same time lower the extraction.

Recleaning Flotation Concentrates

The practice of refloating concentrates produced on rougher cells as a means of increasing their purity is nearly universal at the present time. A short consideration of some of the factors influencing the results obtained by this practice will be of interest.

Successful recleaning of the flotation concentrates in cleaner machines involves several factors: (1) The general idea of all concentration that the grade of the product from a concentrating machine will be higher the richer the feed to the apparatus, (2) the fact that gangue material in flotation concentrate can be eliminated by re-forming the froth under more quiet conditions than those under which it was first produced, (3) making the amount of froth smaller in proportion to the amount of mineral to be lifted, tending to give concentrates of the highest possible grade.

If these facts are true, and they are generally assumed to be so, we can say that the effectiveness of the recleaning or reflotation operation will depend on the following: (1) The ratio between the capacity of the cleaner cells and the amount of the concentrate to be refloated, (2) the purity of the first concentrate produced for recleaning, (3) the skill used in the operation of the recleaning machines, (4) the extraction obtained in the cleaner machines, and (5) the water dilution of the froth being re-treated.

Before proceeding to discuss these points, one fact should be emphasized that is usually assumed to be true but is seldom mentioned: Nearly all minerals have the property of adhering to flotation froth but, of course, in widely differing degrees. An extreme illustration would be the case of limestone and galena. They have both been made to float, and their commercial separation by means of flotation depends only on the degree with which one floats in preference to the other under given conditions.

On this assumption, it follows that when several minerals are present, the most readily floatable will be the first attracted to and carried by the froth, and when the froth has picked up all of the mineral possible and there is still remaining space available this space will then be filled by the next most easily floatable mineral in the pulp, and so on.

With these facts in mind, it should be quite simple to see the importance of having the cleaner cells of a correct size to produce the correct amount of froth to take care of the mineral that is coming to them in the rougher concentrate. As already mentioned, the amount of froth produced on a flotation machine in a given time is a definite and limited quantity. The amount of froth produced, therefore, should be just sufficient to carry the amount of pure mineral that will come to it

from the rougher cells and no more. As the quantity of froth produced will depend on the size of the froth discharge area, other things being equal, the necessity of having the correctly proportioned cleaners should be clear. Practice has shown the above to be true. Several illustrations could be shown where the grade of the final concentrate has been very materially improved by simply decreasing the number of cleaners that were being used.

It follows that the number of cleaner machines in a mill does not depend on the number of rougher machines in the plant but on the number of pounds of concentrate that each rougher produces in a given time.

The effect of grade of feed and its relation to the purity of the cleaner concentrate should be easily seen, especially in view of what has just been said. The higher the grade of the feed to the cleaners, the less are the impurities that are to be eliminated from it, and the less is the work the cleaners will be called upon to do. Usually the grade of the concentrate that is produced for recleaning is determined by the extraction to be made on the roughers, which in turn is determined by economic conditions. This factor is, therefore, to a large extent outside of the control of the operator, except in the more limited sense.

The skill of the operator will probably be shown to a greater extent in the operation of the cleaner cells than in any other manner. He must be taught to run the machines so that just the correct amount of froth will be made and discharged to carry out of the machines the pure mineral that is coming to it, and no more. This can only be done by thoroughly understanding what the machines are expected to do, and closely observing their action from day to day.

It should not be necessary to emphasize the fact that cleaner cells must make the highest extraction possible, consistent with making the necessary grade of concentrate. An excessive loss at this stage of the process only means an excessive quantity of mineral to be returned to the roughers in cleaner tailings, salting the circuit and placing an added load on the roughers, with the increased chance that some of the mineral will be lost in the final tailings, giving an excessively low extraction for the complete operation.

At the same time, it has been shown that grade of concentrate can only be increased by a certain loss in extraction. It is, of course, necessary that the cleaners be so operated that a sufficiently high grade of concentrate is produced. A comparatively poor extraction will therefore be made in the cleaners. Economic considerations will govern this phase of the operation of the cleaner cells. It is common practice, and also logical under many conditions, to operate the cleaners to produce the highest grade of concentrate possible to be made when producing at the same time cleaner tailings equal in valuable mineral to the original rougher feed. This is not always possible, however, and must be governed by other conditions to a great extent.

The last point in the operation of the cleaners is the dilution of the concentrate being cleaned on them. This again brings us to the consideration of the relation of the quantity of froth and the amount of mineral to be saved. The quantity of mineral going to the cleaners should be so regulated that the amount of mineral going to the machine is just sufficient to load the froth. The point that should be watched is to have the pulp dense enough so the mineral actually in the feed will do this. When this is not the condition, it can often be remedied by making less froth on the cleaners or by using less oil on the roughers, causing them to make a froth containing less water. Another remedy would be to reduce the number of cleaners. The desired extraction usually limits the use of these remedies.

When the pulp in the cleaners is too thick and water is needed, only fresh, pure water should be used; under no conditions should return water carrying flotation oil be employed. Return water will carry enough oil to increase the cleaner froth and aggravate the conditions it is used to rectify. The cleaner, to produce concentrate of the maximum purity, should be rather underthan over-oiled.

Conclusions

Several possible sources of unsatisfactory results in the flotation plant have been suggested with possible means for remedying them. In many cases, however, it will be found that the employment of these suggestions will not improve results as had been expected. In most cases, this will not be surprising. When the innumerable factors that can influence flotation results are remembered, it is little wonder that the varying of one or even two of them will make no evident improvement in results. It is only by long contact with the problem, and the understanding of all the various factors and their inter-relations, that the hoped for results are obtained.

Many operators, in striving for perfect metallurgical results, lose sight of the economic side of the situation. Unfortunately, very often, especially in flotation, the correction of or the improvement in one step of the process will only be to the detriment of some other step. This fact must always be borne in mind. When in doubt as to whether the apparent benefits derived from the improvement of some point in the operation are really justifiable, the profit sheet, the true standard of success of all technical operations, should be appealed to for guidance.

Salt Lake City.

Detecting Overheated Bearings

Certain double iodides of mercury with other metals are dimorphic and exhibit a more or less pronounced color change at the transition point. H. T. Pinnock[1] has made a study of these in order to determine which compounds are most suitable for use as visible indicators of overheating in bearings and machinery.

The double iodide of silver and mercury, $AgI.HgI_2$, is a pale lemon yellow powder at ordinary temperatures, but changes to a vivid carmine at 90 to 100 deg. C., the change in both directions being fairly sharp. With copper mercuric iodide, $Cu_2I_2.2HgI_2$, the change from a vivid scarlet vermillion to a chocolate brown takes place at 60 to 70 deg. C. It was found that a mixture of the two, consisting of 85 per cent of the copper salt and 15 per cent of the silver salt, was more sensitive and gave an exceedingly sharp transition from vermillion to almost black at 60 to 70 deg. C.

For application to bearings, etc., these compounds are mixed with white shellac spirit varnish or, for more elevated temperatures, a medium such as is used in aluminium paints for steam pipes, in the proportion of 100 g. compound to 70 cc. of medium. This paint is best applied as a bullseye or band on a zinc white background. After the paint is dry, it should be protected with a coat of colorless oilproof varnish.

[1] J. Soc. Chem. Ind., Mar. 15, 1919, p. 78_R.

The Art of Searching Chemical Literature

By Harold Hibbert

THERE is no more important phase of research or technical work in chemistry than that indicated by the above title. Thus, whether the chemist is concerned with the acquirement of a comprehensive knowledge of the properties of any particular compound for research or technical purposes, or again with matters relating to patent and other litigation, the ability to search the literature rapidly, thoroughly and efficiently is of prime importance, and no less important is the saving of time and money in preventing the "new" discoveries of old facts.

In the first place, in order that the chemist may be thoroughly equipped to carry out an investigation of the chemical literature, it is necessary that he should be able to read both French and German readily, and if he possesses a nodding acquaintance with Russian and Italian so much the better.

It is difficult not to be impatient with the foolishness shown in the outcry against the teaching of German in the public schools and colleges, since no matter what our present feelings may be with regard to the German nation, the fact remains that a very large proportion of our chemical knowledge and scientific facts are only to be found to-day in German periodicals, special treatises and text-books, so that it is imperative on the part of the future chemist to acquire a good thorough knowledge of this language.

In this article the question of conducting a search of the chemical literature will be dealt with more from the point of view of the technical chemist than from that of the university student. At certain schools of chemistry such as the Universities of Illinois and Pittsburgh, it is understood that special courses of from six to eight lectures are given on this subject, and in connection therewith, actual practical work carried out relating to literature research and abstracting.

It would be an admirable thing if this scheme could be extended to all of our leading colleges and the full lecture course published in book form for the benefit of chemists in general.

The method of conducting a search of chemical literature will vary depending on whether the product to be investigated is of organic, biochemical, inorganic or mineral origin, and the question of the method to be adopted in the case of organic derivatives will be first discussed.

The Search of Organic Chemical Literature

With regard to this field, if it is only desired to ascertain from the analysis of a certain new product whether its properties correspond to those of some substance already known, the matter is much simpler than where we are concerned with the desire to ascertain whether the product in question has been either (*a*) made previously by any method, or (*b*) made previously by a specified method, or (*c*) where we desire information regarding the chemical behavior of the compound.

Scheme 1. If the chemist is merely concerned with the properties and identification, it is sufficient for him to determine first of all its empirical composition and then by reference to Richter's Lexikon der Kohlenstoffverbindungen 1910-1912 or better, the Stelzner Literatur-Register der Organischen Chemie 1910-11, in case the derivative is to be found in the latter, to obtain the corresponding reference to the product in Beilstein's Organische Chemie, from which, by perusing both the original and supplementary volumes, the desired information can in general be obtained. If the physical properties such as specific gravity, refractive index, melting-point, boiling-point, etc., are not given, they can very frequently be obtained by referring to the journals in which the various researches on the subject are published.

In many cases, as regards the physical and chemical properties of the derivatives, much time may frequently be saved by referring in the first instance to well known reference books such as:

(a) 1. Kaye and Laby—Tables of Physical and Chemical Constants (1918).
2. Liddell—Metallurgists' and Chemists' Handbook (1916).
3. Chemical Rubber Co.—Handbook of Chemistry and Physics (1919).
4. Van Nostrand's Chemical Annual.
5. Landolt-Bornstein Phys. Chem. Tabellen.
6. Mullikin—Identification of Organic Compounds (1911-1916).
7. Rosenthaler—Der Nachweis organischer Verbindungen (1914).
8. Biedermann—Chemiker Kalendar (1916).
9. Seidell—Solubilities of Inorganic and Organic Substances (1911).
10. Comey—Dictionary of Chemical Solubilities (1896). (New edition in the press.)
11. Tables—Annuelles (1912-1914).
12. Fowle—Smithsonian Physical Tables.

Scheme 2. On the other hand, the chemist may wish to ascertain the best method for making a specified organic derivative. In this case he should first follow the method outlined under Scheme 1, and then from the references given consult the original literature.

In addition to this, he should review the decennial indexes (author and subject) of

(b) 1. Chemical Abstracts (Amer. Chem. Soc., 1907 —).
2. Chemisches Centralblatt (1830 —).
3. Berichte der deutschen chemischen Gesellschaft (1868 —).

as well as the following text-books and encyclopædias:

(c) 1. Meyer - Jacobson — Lehrbuch der organischen Chemie (1907).
2. Richter—Chemie der Kohlenstoffverbindungen (1894).
3. Bender-Erdmann—Chemische Präparatenkunde (1893-1894).
4. Schmidt—Ausführliches Lehrbuch der pharmazeutischen Chemie (1910).

(d) 1. Ullmann—Enzyklopaedie der technischen Chemie (2 vols.), 1914-1915.
2. Molinari—Treatise on general and industrial organic chemistry (2 vols., trans. Pope, 1912-1913).
3. Vanino—Handbuch der präparativen Chemie (1914).
4. Thorpe—Dictionary of Chemistry (5 vols., 1912-1913).
5. Watts—Dictionary of Chemistry (4 vols., 1911-1914).
6. Ure—Dictionary of Arts, Manufactures and Mines (4 vols., 1867-1878).
7. Dammer—Chemische Technologie der Neuzeit (3 vols., 1910-1911).
8. Blücher—Auskunftsbuch für die chemische Industrie (8th Ed., 1913).
9. Sadtler—Industrial Organic Chemistry (4th Ed., 1912).

(e) 1. Weyl—Die Methoden der organischen Chemie (2 vols., 1911).
2. Lassar-Cohn—Arbeitsmethoden (4th Ed., 1907).

If the chemist desires to manufacture a product by some scientific process involving purity of material

rather than a consideration of yield, the methods referred to in the literature under (*b*) will probably best answer his purpose.

On the other hand if he wishes to ascertain the best method for producing a product commercially, that is, under conditions where the yield is probably more important than scientific purity, more detailed information is likely to be found in the literature quoted under (*d*) and (*e*).

The two volumes quoted under (*e*) are very valuable from the point of view of giving the research and technical chemist important information as to the various devices and schemes incidental to oxidation, reduction, hydrogenation, chlorination, etc., which have been found useful in overcoming the experimental difficulties relating to the synthesis of a wide variety of organic derivatives. Very frequently by referring to the index for the particular derivative in question (or failing this, the next lowest or related member of the series) the desired information can at once be obtained.

In this connection it is felt that where important processes are published in scientific journals, difficult for the average man to read or translate, the American Chemical Society should give even fuller abstracts so that it would be possible to repeat the work without having to consult the original. These remarks are made with special reference to the valuable scientific data published by the Russian Chemical Society.

Scheme 3. It frequently happens that the chemist is called upon to make a thorough search of the literature either for the purpose of obtaining a complete knowledge of the subject or for patent or other purposes of litigation, and in this case a more careful and elaborate study is necessary.

In the first place much of the earliest information, modes of preparation, and properties of organic derivatives are not to be found in Beilstein, so that at the outset a thorough search should be made through volumes such as:

(*f*) 1. Erlenmeyer—Handwörterbuch der Chemie.
2. Fehling—Handwörterbuch der Chemie (8 vols., 1871-1913).
3. Kolbe—Ausführliches Lehr- und Handbuch der organischen Chemie (3 vols., 1880).
4. Muspratt—Chemistry as Applied to Arts and Manufactures (2 vols., 1860).
5. Muspratt—Theoretische praktische u. analytische Chemie (10 vols., 1886 —).

Having gone carefully through these treatises, he is then ready to study the original and supplementary volumes of Beilstein, as a result of which the literature relating to the particular derivative in question, as well as to its closely related analogues, should have been carefully abstracted.

The latter procedure is of importance, since it often happens that valuable information, while not disclosed in the literature relating to a given product, is frequently quoted in a description of a closely related derivative. Thus a process for reducing nitroxylene might not be found, let us say, under xylidine, but might be found by studying the preparation and properties of the corresponding toluidine.

In general the next procedure would be to go carefully through the yearly indexes of list (*b*), which, though somewhat laborious, enables a thorough search to be made. If as a result of this review a still more thorough and complete one is deemed necessary, the following journals should then be carefully abstracted:

(*g*) 1. Dingler—Polytechnisches Journal (1820 —).
2. Wagner-Fischer—Jahresbericht (1855 —).
3. Kopp-Fittica—Jahresbericht über die Fortschritte der Chemie (1847 —).
4. Biedermann—Technisches Chemisches Jahrbuch.

(*h*) 1. Meyer—Jahrbuch der Chemie (1891 —).
2. Chemisches Centralblatt (1830 —).
3. Journal of American Chemical Society, Abstracts (1907 to date).
4. Journal of Chemical Society, London, Transactions and Abstracts (1849 —).
5. Comptes Rendus (1835 —).
6. Bulletin de la société chimique (1861 —).
7. Liebig—Annalen der Chemie (1832 —).
8. Berichte der deutschen chemischen Gesellschaft (1868 —).
9. Journal für praktische Chemie (1828 —).
10. Monatshefte für Chemie (1880 —).
11. Annales de chemie et de physique (1792 —).

Those listed under (*g*) are particularly valuable as reference works to the older literature, especially in patent cases and chemical litigation, while those given under (*h*) contain a fuller account of recent investigations. Advantage should always be taken of the fact that in many cases the decennial indexes may be consulted, thus saving considerable time. Furthermore, information is often obtained in a somewhat roundabout fashion, as for instance with regard to certain acetyl derivatives, by reviewing the properties of acetyl chloride or acetic anhydride on the one hand, and those of the amino or hydroxy derivative on the other.

The chemist will naturally be guided by such questions as the nationality and location of the men who have worked in this particular field as to the probable source of references covering the particular subject, so that very frequently much time may be saved by consulting such journals immediately without going through the whole of those specified above.

If the subject relates to dyestuffs or their intermediates, search should be made through the following journals and text-books:

(*j*) 1. Friedländer—Fortschritte der Theerfarbenfabrikation (1877 —).
2. Zeitschrift für Farben- und Textil-Chemie (1902 —).
3. Bulletin de la Société industrielle de Mulhouse (1831 —).
4. Bulletin de la Société d'encouragement pour l'industrie nationale.
5. Knecht, Rawson and Lowenthal—Manual of Dyeing.
6. Bucherer—Lehrbuch der Farbenchemie (1914).

If the search relates to a patented process, then a review should be carried out of

7. Winther—Patente.
8. Friedländer—Fortschritte der Theerfarbenfabrikation (1877 —).

In general, it may be said that when it is necessary to make a thorough investigation of the patent literature, it is, as a rule, advisable to confide this to some well known patent attorney, not only versed in patent law, but also possessing more than a passing acquaintance with chemistry, since the methods employed for locating foreign and other patent references call for specialized training.

The classified compendia issued by the British Patent Office will be found very useful in connection with research and especially patent investigations. As the British office data are classified according to subject they provide a valuable aid in reviewing the patent situation relating to any specific product.

It frequently happens that the chemist is called upon to ascertain whether some process has been tried out

previously on a technical, as distinct from a scientific scale, and in this case he should consult special monographs, and text-books on the subject, extending the search to all monographs, university theses, government and other special treatises dealing with the subject.

Certain technical journals dealing especially with applied chemistry should also be reviewed, for example:

(k) 1. Journal of Industrial and Engineering Chemistry (1909 —).
2. Chemical and Metallurgical Engineering (1902 —).
[Electrochemical Industry, I-II, 1902-1904; Electrochemical & Metallurgical Industry, III-VII, 1905-1909; Iron & Steel Mag. combined with last named, IV, 1906; Metallurgical & Chemical Engineering, VIII-XVIII, 1910-1918[1]; Chemical & Metallurgical Engineering, XIX- —, 1918[2]- —.]
3. Journal of the Society of Chemical Industry 1882 —).
4. Zeitschrift für angewandte Chemie (1887 —).
5. Revue générale de Chemie pure et appliquée (1899 —).
6. Chemiker Zeitung (1877 —).
7. Die Chemische Industrie (1878 —).
8. Revue de chimie industrielle (1890 —).

When the search relates to a specific subject such as explosives, rubber, pharmacology, gas, water, hygiene, etc., the special journals and text-books relating to them should be reviewed.

Search of Literature on Biochemistry

In view of the marked developments in the domain of biochemistry, it becomes of increasing importance for the organic chemist to keep in touch with this work. One of the best text-books on the relation between physiological action and constitution is Fränkel's Die Arzneimittel-Synthese.

For special methods reference should be made to:

Oppenheimer—Die Fermente und ihre Wirkungen (4th Ed., 2 vols., 1913).
Oppenheimer—Handbuch der Biochemie (4 vols. and supplt., 1908-1913).
Abderhalden—Handbuch der biochemischen Arbeitsmethoden (8 vols., 1910-1915).
Abderhalden—Lehrbuch der physiologischen Chemie (2 vols., 1914-1915).
Abderhalden—Physiologisches Praktikum (1912).
Hoppe-Seyler—Handbuch der physiologisch-und-pathologisch-chemischen Analyse (5th Ed., 1883).

For detailed information Abderhalden's Biochemisches Handlexikon (1911-1915) should be consulted.

In addition to these there is an excellent series of English monographs on biochemistry published by Longmans, Green & Co., and embracing fats, enzymes, proteins, etc.

List for a More Complete Search

If it is desired to make a more complete search of the literature, the following journals should be consulted:

1. Chemical Abstracts (1907 —).
2. Chemisches Centralblatt (1830 —).
3. Hoppe-Seyler—Zeitschrift für physiologische Chemie (1877 —).
4. Maly—Jahresbericht über die Fortschritte der Tierchemie (1871 —).
5. Centralblatt für Biochemie.
6. Centralblatt der exp. Medizin.
7. Koch — Jahresbericht über Gährungs-Organismen (1890 —).
8. Hofmeister—Beiträge über chemische Physiologie und Pathologie.
9. Biochemische Zeitschrift (1906 —).

Chemical Abstracts now makes a very complete review of work in this field. The earlier work is to be found by consulting the volumes indicated under lists *(g)* and *(h)*.

Inorganic and Mineral Chemistry

Unlike the literature of organic chemistry, where we have in Beilstein a "first aid" for the majority of inquiries, that of inorganic and mineral chemistry is scattered throughout the journals, books, monographs, etc.

In the first place, for reference to the general literature, the chemist should consult in the order named:

(p) 1. Gmelin-Kraut — Handbuch der anorganischen Chemie (5 vols., 1907-1914).
2. Hofman — Dictionary of the Inorganic Compounds (16 vols., 1910-1915).
3. Abegg — Handbuch der anorganischen Chemie (4 vols., 1905-1913).
4. Moissan—Traite de Chimie Minerale (5 vols., 1904-1906).
5. Dammer—Handbuch der anorganischen Chemie (5 vols., 1898).
6. Roscoe and Schorlemmer—Treatise on Chemistry (2 vols., 1911-1913).
7. Remsen—Inorganic Chemistry (5th Ed., 1907).
8. Molinari—General Industrial Chemistry (trans. Pope, 2 vols., 1912-1913).
9. Mellor—Modern Inorganic Chemistry (1912).

while other volumes of interest are:

10. Thorpe—Dictionary of Chemistry (5 vols., 1912-1913).
11. Watts—Dictionary of Chemistry (4 vols., 1911-1914).
12. Wurtz—Dictionaire de Chimie pure et appliquée (7 vols., 1892-1908).
13. Stähler—Handbuch der Arbeitsmethoden in der anorganischen Chemie (1913).

In addition the following journals should be reviewed:

(q) 1. Chemical Abstracts (1907 —).
2. Journal Chemical Society, Transactions and Abtracts (1849 —).
3. Chemisches Centralblatt (1830 —).

In general a good plan to follow is first of all to review thoroughly these three journals, list *(q)*, and then to proceed, according to the nature of the subject under review, to those journals which specialize in this field.

Mining and Metallurgical Chemistry

The chemist looking for specialized information will have to seek the same in a variety of text-books and publications, for example:

(a) Production of Metals.
(r) 1. Hofman—General Metallurgy (1913).
2. Roberts-Austen—An Introduction to the Study of Metallurgy (6th Ed., 1910).
3. Roberts-Austen—Metallurgy of the Common Metals.
4. Fulton—Principles of Metallurgy (1910).
5. Schnabel—Handbook of Metallurgy, Trans. H. Louis, 2 vols. (1905-1907).
6. Schnabel—Lehrbuch der allgemeinen Hüttenkunde, 2nd Ed., (1903).
7. Mineral Industry (1892 —).

and a variety of special treatises on individual metals such as

Peters—Copper Smelting.
Hofman—Metallurgy of Copper.
Clennell—The Cyanide Handbook.
Hofman—Metallurgy of Lead.
Ingalls—Metallurgy of Zinc and Cadmium.
Stoughton—Metallurgy of Iron and Steel.
Rose—Gold.

(b) Properties of Metals and Alloys.
(s) 1. Guertler—Metallographie (1912-1913).
2. Giua—Chemical Combination Among Metals (1918).
3. Howe—Metallurgy of Steel.

4. Howe—The Metallography of Steel and Cast Iron (1916).
5. Howe—Iron, Steel and Other Alloys (1906).
6. Law—Alloys and Their Industrial Application (1909).
7. Thurston—Treatise on Brasses, Bronzes, and Other Alloys and Their Constituent Metals.
8. Desch—Metallography (2nd Ed., 1913).
9. Ruer-Matthewson—The Elements of Metallography.
10. Sauveur—Metallography of Iron and Steel.

The following journals are devoted essentially to the subjects of mining and metallurgical chemistry:

(c) Mining Chemistry.
(t) 1. Engineering and Mining Journal (1869 —).
2. American Institute of Mining and Metallurgical Engineers—Bulletin and Transactions (1871 —).
3. Mining and Scientific Press (1848 —).

(d) Metallurgical Chemistry.
(u) 4. Chemical and Metallurgical Engineering (1902 —).
5. Journal of Institute of Metals (1909 —).
6. Internationale Zeitschrift für Metallographie (1911 —).
7. Iron Age (1834 —).
8. Journal Iron and Steel Institute (1869 —).
9. Brass World and Platers' Guide (1905 —).
10. La Metallurgie (1868 —).
11. Stahl und Eisen (1881 —).
12. Berg- und Hüttenmännische Zeitschrift — formerly Glückauf (1865 —).

(e) Applied Electrochemistry.
(v) 1. Transactions of American Electrochemical Society (1902 —).
2. Transactions of the Faraday Society (1905 —).
3. Electrical World (1883 —).
4. Zeitschrift für Electrochemie (1894 —).
5. Chemical & Metallurgical Engineering (1902 —).

The one journal devoted essentially to inorganic chemistry is Zeitschrift für anorganische Chemie (1892 —), while information of value is often to be found in Zeitschrift für angewandte Chemie (1887 —).

This is not intended to serve in any sense as a complete guide to the subject, but only as a general outline which will, it is believed, serve as a useful help and general guide. The ability to search the literature rapidly and efficiently is in part a question of experience especially as regards the various "short cuts" which can only be effected as a wider grasp of the field is acquired.

Special Literature for Specific Information

There is, in connection with each particular group, a certain definite territory consisting of special monographs, dissertations, journals, encyclopedias, etc., and the chemist will naturally direct his attention to them for specific information.

The abstract journal of the American Chemical Society is now covering the entire field in very complete fashion.

Certain of the journals have changed their names at various times—a fact to be borne in mind in reviewing the earlier literature. Furthermore the periodical indexes vary considerably as to the periods abstracted, and with regard to this point the chemist should consult the Catalogue of Scientific and Technical Periodicals (1665-1895), 2nd Ed. (1897), by Bolton, published by the Smithsonian Institution.

General Indexes

For information regarding titles and dates of publication of books, monographs, etc., on chemistry and allied subjects the following general indexes should be consulted:

1. Roorbach, O. R.—Bibliotheca Americana (1820-1861).
2. Kelly, J.—American Catalog of Books published in U. S. from Jan., 1861, to Jan., 1871.
3. Publishers Weekly — American Catalog of Books (1876-1910).
4. United States Catalog—Wilson & Co. (1900 —).

The last named is a five-yearly compilation of the "Cumulative Book Index"—Annual Catalog published by Wilson & Co.

In order that a technical chemist may keep up to date it is advisable that he should read regularly at least four or five journals, for example:

1. Journal of the American Chemical Society.
2. Chemical Abstracts.
3. Journal of Industrial and Engineering Chemistry.
4. Chemical and Metallurgical Engineering.
5. Journal of the Society of Chemical Industry.

The first two will give the chemist a fairly complete knowledge of the scientific chemical work being carried out in this and other countries, while the third and fourth will provide him with information on recent work and developments being carried out along technical lines. The fifth is valuable as a reference journal for information relating to patented processes, both here and abroad, and which are reviewed at greater length than in *Chemical Abstracts*.

The author wishes to acknowledge his appreciation of the kindness of the following gentlemen in favoring him with their criticism, suggestions and advice:

Dr. Colin Fink, Director Research Laboratories, Chile Exploration Copper Company, New York City; Dr. Roger Brunel, Professor of Chemistry, Bryn Mawr College, Bryn Mawr, Pa.; Mr. W. A. Hamor, Assistant Director Mellon Institute of Industrial Research, Pittsburgh, Pa.

360 Garden Ave.,
Mount Vernon, N. Y.

Manganese Ore

The United States Tariff Commission has recently completed the assembling of information on the manganese ore mining industry and has prepared an analysis of the competitive position of the United States in the manganese industry of the world. Among interesting facts recorded are the following:

Domestic production of high-grade (i.e., 35 per cent or more manganese) ore used largely for making ferromanganese increased from 4,063 tons in 1913 to about 294,000 tons in 1918. Production of low-grade (less than 35 per cent manganese) ore, used partly for making spiegel and partly smelted direct in iron furnaces, increased from 85,588 tons in 1913 to over 1,079,000 tons in 1918. The number of shippers of high-grade ore in 1918 had increased from 75 in 1917 to about 210.

Manganese mining on a large scale in the United States, however, is an artificial industry. The domestic ore is low grade, obtainable in small lots only, and variable in character. Aside from the higher cost of domestic ore as compared with the foreign product, any large dependence on domestic supplies involves the rapid depletion of our limited reserves.

The foreign resources are in some instances practically inexhaustible, are high grade and are more easily mined than the domestic deposits. The average grade of imported ore is 45 to 55 per cent manganese, compared with domestic "high grade" running 35 to 45 per cent.

Use of Army Gas Masks in Atmospheres Containing Sulphur Dioxide*

Adequate Protection Obtained From Army Gas Masks in the SO_2 Industries — Physiological Effect of Sulphur Dioxide — Canisters: Duration, Special Fillings and Sizes — Limitation of Gas Masks

By A. C. FIELDNER and S. H. KATZ

THE use of toxic gases in warfare has led to the development of an entirely new type of respiratory appliance, namely, the gas mask, which promises to fill a long-felt want in the chemical and metallurgical industries. Heretofore, workmen around plants using processes in which acid fumes are given off made shift to protect themselves, in more or less inadequate manner, by wearing moistened handkerchiefs, or respirators containing wet sponges, over the mouth and nose. The close of the war now makes available the army type gas mask, which is admirably adapted to filtering out many chemical fumes and acid vapors from inspired air, provided the concentration of gas is low (less than 1 or 2 per cent).

The possibility of using army masks around smelters and sulphide roasters for protecting the workmen from sulphur dioxide fumes was suggested, almost a year ago, by Mr. George S. Rice, chief mining engineer of the Bureau of Mines, and at his request several patterns of army masks were tested in various concentrations of sulphur dioxide to determine the degree of protection afforded. Owing to the pressure of military work and the inability of obtaining masks for industrial use, this investigation was not completed until after the signing of the armistice. The work is now completed, and the results are given in this publication.

Physiological Effect of Sulphur Dioxide

Sulphur dioxide is an irritating, irrespirable gas, relatively non-toxic as compared to carbon monoxide or oxides of nitrogen. There is very little danger from sulphur dioxide poisoning, as the fumes are so irritating that the victim is compelled to seek air at once. In extreme cases[1] of very high concentrations, when the victim cannot retire from the fumes, death may result from respiratory spasms and asphyxia. Ordinarily, however, workmen exposed for some time to a mild degree of sulphur dioxide poisoning complain of headache, anorexia, spasmodic cough, sneezing, hernoptysis, bronchitis, constriction of chest, gastro-intestinal disorders, conjunctivitis, smarting of eyes, lachrymation and anemia. For these symptoms workmen soon acquire toleration. The inhalation of large quantities of sulphur dioxide produces ulceration of the mucous membrane.

The Selby Smelter Commission[2] made a thorough investigation of the effect of various concentrations of sulphur dioxide on the senses of a number of persons. The average results of these tests are tabulated below:

Three to 5 parts per million (by vol.)—Plainly or faintly detectable by smell or taste.

Eight to 12 parts per million (by vol.)—Slight throat irritation and tendency to cough.

Twenty parts per million—Very distinct throat irritation, coughing, constriction of chest, lachrymation and smarting of eyes.

Fifty parts per million—More pronounced irritation of eyes, throat and chest, but possible to breathe several minutes.

One hundred and fifty parts per million (by vol.)—Extremely disagreeable but could be endured for several minutes.

Five hundred parts per million—So acutely pungent as to cause a sensation of suffocation, even with the first breath.

With no concentrations of less than 50 parts per million was there produced any feeling of nausea, and the tendency to nausea with the highest concentrations was only slight.

The authors repeated some of these experiments with substantially the same results; 370 parts per million (0.037 per cent) could be endured for only one-half minute.

Tests of Army Gas Masks

Early French Type:—The early French type of mask, shown in Fig. 2, consists of 40 thicknesses of cheesecloth, fashioned to fit over the entire face, from neck over chin to the hair above the eyes from ear to ear. Suitable rubber web bands held the mask closely to the face. Cellophane eyepieces were built into the mask at the eyes. The 10 outside layers of cheesecloth were impregnated with an unsaturated oil; the next 10 layers held an alkaline material; the next 10, hexamethylene tetramine; and the 10 next the face, nickel sulphate. The tests were made in a large airtight gas chamber, in which the sulphur dioxide atmosphere was produced by burning sulphur. The air was well stirred by two electric fans, running continuously throughout the tests. The concentration of sulphur was determined by titration with iodine. After the required concentration was reached, two observers, wearing carefully adjusted masks, entered the room. The results are given in Table I.

From the experiments in Table I it may be concluded that an atmosphere containing 0.16 per cent of sulphur dioxide may be safely entered and work performed by a person wearing a mask such as used in the experiments. Even though a mask were worn, it would be dangerous to attempt work in an atmosphere containing 0.20 per cent of sulphur dioxide, unless means of immediate exit were at hand and an observer watching from a place of safety to effect a rescue in case of necessity.

Prolonged exposure to sulphur dioxide, even in moderate concentrations, is undoubtedly injurious. Five

*Published with the permission of the Director, Bureau of Mines.

[1] Thompson, D. Gilman, M. D., "The Occupational Diseases." D. Appleton & Co., New York, 1914, p. 360.

[2] Holmes, J. A., Franklin, E. C., and Gould, R. A., "Report of the Selby Smelter Commission," Bureau of Mines, Bull. 98, pp. 172-175.

hours after the close of the above experiments, the observer who had been most exposed felt a soreness through the lungs and throat and the voice was slightly husky. The discharge from the nose was increased, and was slightly pink from blood. The next day he felt normal.

TABLE I—EFFECTS PRODUCED BY ATMOSPHERES CONTAINING VARIOUS PROPORTIONS OF SULPHUR DIOXIDE ON PERSONS WEARING FRENCH PATTERNED MASKS, FIG 2.

Test No.	Time	SO_2 by Iodine Per Cent	Effect on Wearer of Apparatus in Atmosphere
..	2:15	0.57	
1	2:31:00 to 2:31:45	....	Sulphur dioxide penetrated masks. The eyes could feel it, but were not disturbed much. The biting was severe in the air passages of the nose and throat. It could also be felt in the bronchial tubes and lungs. Observers could remain in this atmosphere only 45 seconds.
..	2:46	0.43	
2	2:58:00 to 3:03:00	....	The observers could just bear the sulphur dioxide that came through the masks. The biting in the air passages extended all the way to the lungs. Coughing was caused. The eyes were not bothered. The breathing was deep and difficult. In case of necessity, one could probably travel ½ mile in this condition. It was thought best not to remain in this atmosphere longer than 5 minutes. After coming into the fresh air, all the sulphur dioxide disappeared from the mask after three inhalations.
3	3:24:00 to 3:27:00	0.24	At first, one of the masks leaked at the sides, so that the eyes were bothered. After fixing this, the atmosphere was much better. The biting in the air passages was not so severe, but coughing was caused. It is probable that one could stand this atmosphere one hour, in case of necessity.
4	4:00	0.16	No difficulty was experienced in this atmosphere. The sulphur dioxide was noticeable and the throat was slightly irritated, but work could be done with hardly more trouble than that due to the mask itself.

Discomfort Caused by the Mask

The French type mask is an unpleasant apparatus to wear at best, although it imposes no marked hardship on the wearer. The face is heated, and the atmosphere breathed necessarily contains much exhaled air, and is hot and close. To determine the composition of the atmosphere within a mask while worn by a person at rest, two samples of gas were taken from a point ½ in. above the nostrils, the first, during periods of exhalation, the second, during periods of inhalation. The results are given in Table II.

TABLE II. COMPOSITION OF ATMOSPHERE WITHIN MASK WHILE WORN IN PURE AIR

No.	CO_2	O_2	N_2	
1	2.90	17.41	79.69	Sample taken during exhalation.
2	1.37	19.15	79.48	Sample taken during inhalation.

These tests show the bad effect of the large "dead space" in this type of mask. Even while at rest the wearer has to inhale 1.37 per cent of carbon dioxide, which contributes to the oppressive feeling produced by this mask. Aside from the question of rebreathing a certain proportion of exhaled air, this type of mask furnished so little protection against sulphur dioxide that it is of no practical value for use in the industries.

Mouthpiece Type U. S. Army Mask

The standard U. S. Army gas mask of the mouthpiece type is shown in Figs. 4, 7, 8 and 9. It consists essentially of a facepiece of rubberized fabric, impermeable to gas, connected to a canister containing the absorbents by a short length of flexible rubberized tubing. The wearer breathes through a rubber mouthpiece, the nose being closed by a spring clip, mounted on the inside of the mask. Leakage through the facepiece will only affect the eyes of the wearer, as the gas cannot enter the lungs. The inhaled air enters the bottom of the canister through a disk valve that closes on exhalation, the expired air passes out through a rubber flutter valve, projecting downward from the metal elbow tube just outside the facepiece.

The Type "F" standard army canister shown in section in Fig. 8 is 5½ in. high and contains 42 cu. in. of a mixture of cocoanut charcoal and "purple" soda lime and two cotton wadding filter pads, placed at one-third and two-thirds distance from the bottom, respectively. One of the authors, wearing this outfit, entered the gas chamber containing a concentration of 0.46 per cent sulphur and remained one hour, without detecting any gas whatever, except on one occasion, when the mask was disarranged, and then sulphur dioxide penetrated to and irritated the eyes. On adjusting the mask and clearing the facepiece, the gas disappeared, and no discomfort whatever was experienced thereafter from that source. During a part of the time, work was done on a bicycle dynamotor.

More sulphur was then burned, until a fog was produced in which objects could not be distinguished at distances beyond 4 ft. Analyses showed that the concentration was 1.17 per cent sulphur dioxide. No discomfort of any kind could be felt by the wearer, other than that due to the mask itself.

Life of Canisters in High Concentrations

Tests were made to determine the life of the standard Type "F" army canister in an atmosphere containing 5 per cent sulphur dioxide. The gas was put up in the chamber from a cylinder of liquid sulphur dioxide, attached to the chamber. Analyses of the chamber gas were made by drawing two liters of gas through a standard iodine solution and titrating back with standard sodium thiosulphate solution. Twenty canisters were tested, in lots of 10 each. The men did not enter the chamber, but were seated on the outside, wearing the facepieces, which were connected to iron pipes that passed through the walls of the chamber. The canisters were attached to the other end of these pipes on the inside of the chamber. As soon as a man detected gas coming through his canister, as shown by throat irritation, the time was taken, and the canister was considered exhausted.

Tested under these conditions, the 20 canisters served to remove all sulphur dioxide for periods of time varying from 18 to 41 min. The average service time was 29 min. The large variation in service time for the individual canisters was due, in part, to differences in the canister fillings, but mostly to differences in the breathing rates of the men. Individuals breathe different amounts of air. A small man may breathe only 5 liters per minute when at rest, while a large individual may require 10 or 12 liters. The average rate of a number of men, when at rest, is in the neighborhood of 8 liters per minute. Moderate exercise increases the rate to approximately 30 liters, and vigorous exercise causes a breathing rate of 60 to 70 liters. Hence, the efficient life of a gas mask canister is proportionately less when the wearer is engaged on continuous work.

In making these tests with high percentages (5.07 per cent) of sulphur dioxide, the canisters became quite warm after 15 min. use. A temperature of 80 deg. C.

was noted in some of the canisters. This elevated temperature made breathing rather uncomfortable toward the end of the test; however, all the men were able to continue breathing through the canisters until the gas finally penetrated the absorbent.

Practical Tests by Anaconda Copper Mining Co.

Several army masks of the mouthpiece type, Figs. 4, 7, 8 and 9 fitted with standard Type "F" canisters, containing soda lime and charcoal mixture with two cotton wadding filter pads, were tested under practical conditions by Mr. James Kane Murphy, assistant superintendent of the Washoe Reduction Works of the Anaconda Copper Mining Co., at Anaconda, Mont. The following paragraphs are quoted from his report:

"On Oct. 23, 24 and 25, we had considerable repair work to do on one of our Cottrell treaters; this treater takes one-quarter of the gas from roaster No. 2. During the repair work on this treater, it was shut off as tight as possible, but there was such a leakage of SO_2 gas that it was impossible for a man to enter the treater to do any work. The iron workers repairing this treater were able, two at a time, to put on these masks, and do their repair work in the treater. The men stayed in about 20 min. at one time; by that time, the heat and dust caused them to come out, but the masks were very satisfactory and work could be done with them by proceeding slowly.

"One test on these masks was performed in the No. 2 roaster ventilating tunnels when flotation calcine was drawn into cars ahead of the man with the gas mask on. It is absolutely impossible for a man without a mask even to attempt to stay in this place. Most of the dust coming from the cars, which were being loaded ahead of the man with the gas mask, will pass through 200 mesh, but none of the men wearing a mask in this place had any trouble with dust.

"A third mask was tested in a very high concentration of gas. The mask was carefully adjusted about the face and the person making the test was in an atmosphere containing about 5 per cent SO_2. Mr. E. A. Bernard, superintendent of calcining, personally put the mask on in this atmosphere, besides two other men. All decided that the gas came through the canister. This test was made on gas from the top hearth of an Anaconda type roaster furnace. The hearths on this furnace are similar to a Wedge roasting furnace. A steady wind was blowing against the east side of the furnace, so all doors on the top floor were opened, thus forcing a good part of the furnace gases out of the west doors. The testers stood as close as possible to the doors through which the gas came. This gas contains some SO_3, considerable moisture, dust, and some As_2O_3, besides the SO_2.

"If possible, we would like to have two more canisters for further testing of these masks, as they have proved to be very valuable in certain places, from the industrial point of view."

This reports that the simple army gas mask is exceedingly valuable around sulphide roasters and in fact any industry in which sulphur dioxide is given off. The third test, in which gas penetrated the canister, illustrates the limitation of this type of protective appliance. It must not be used in too high a concentration of gas. In this case, the percentage of SO_2 was probably higher than 5 per cent, as tests at the American University Experiment Station of the Chemical Warfare Service have shown that the standard army canister will remove 5 per cent of sulphur dioxide for at least 15 minutes.

Special Canister Filling for Sulphur Dioxide

The standard army canister contains 40 per cent soda lime and 60 per cent charcoal. The charcoal is of less value in absorbing sulphur dioxide than soda lime. Hence, for use in sulphur dioxide and dust an all soda-lime canister with cotton wadding filter pads will last from 50 to 100 per cent longer than the standard canisters used in the Anaconda tests. This is shown in the comparative canister tests with different fillings against ½ per cent SO_2.

TABLE III—SERVICE TIMES OF CANISTERS WITH STANDARD AND SPECIAL FILLINGS

SO_2 Concentration, 0.5% or 13.0 Mg per Liter; Relative Humidity, 50%; Average Temperature, 26° C.

Canister Filling	Service Time in Minutes	
	First Trace of Penetration	0.005 Per Cent SO_2 in Effluent
*Standard, 50 per cent charcoal, 40 per cent soda lime	32	36
Special, 100 per cent charcoal	7	57
Special, 100 per cent soda lime	54	..

* Average of five canisters tested.

The life or service time of the canister is the time in minutes during which all traces of SO_2 are absorbed by the canister. The breakdown of the canister is shown by the change in color of a sensitive potassium iodide-starch solution through which the effluent air from the canister is bubbling during the test.

Advantages of Larger Canister for Industrial Use

The standard army canister described in the foregoing tests contains 42 cu.in. of absorbent, weighs 1⅜ lb. and has a resistance to flow of 3½ to 4 in. water column at 85 liters per minute flow. This high resistance obliges men to work rather slowly while wearing the mask. A second disadvantage to which Mr. Murphy has called special attention is the short service time of the absorbent.

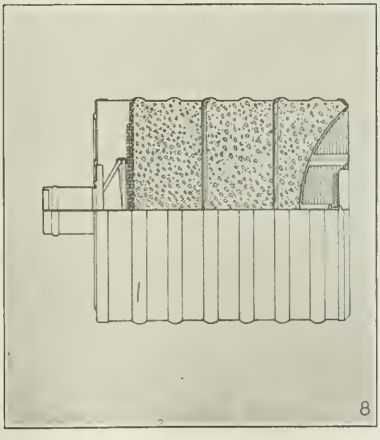
Both of these defects can easily be remedied by increasing the cross-sectional area of the canister without increasing the height in proportion.

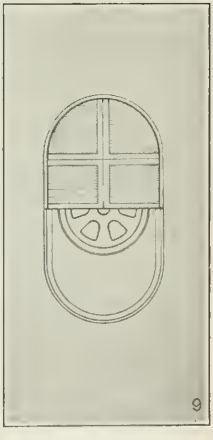
Recommended Type of Gas Mask

Although the mouthpiece type of mask was found fairly satisfactory in practical use, it is believed that the later type of Tissot mask, Figs. 5 and 6, in combination with a 100 cu.in. soda-lime canister will prove the best outfit for exclusive use in sulphur dioxide and acid gases. The elimination of mouthpiece and noseclip increases very materially the comfort, and enables the wearer to keep it on for hours at a time. The large eyepieces, held rigidly in proper position by the well-fitting substantial facepiece, afford a large angle of vision, thereby greatly increasing the efficiency of the workman wearing the mask. He should be able to do substantially the same amount of work as without the mask in a normal atmosphere.

Other Industrial Uses of Sulphur-Dioxide Respirators

Aside from the many metallurgical operations in which sulphur dioxide is given off, a respirator or gas mask designed for this purpose should be useful in sulphite pulp and paper mills; in sulphuric acid plants and





TYPES OF GAS MASKS USED IN WAR

1, Black veil with absorbent cotton saturated with sodium thiosulphate, carbonate and glycerine, effective against active gases such as chlorine. 2. Early French mask. 3. P. helmet saturated with $NaOC_6H_5$—effective against phosgene. 4. British type mask, mouthpiece and wiping fold. 5 and 6. Tissot masks, air inlet at eye, no noseclip or mouthpiece. 7, 8 and 9. Sectional drawings of British type U. S. A. mask.

in fact for protection against any acid gas such as chlorine, phosgene, carbon dioxide, hydrocyanic acid, oxides of nitrogen and hydrochloric acid.

Limitations of Gas Masks

In closing this paper, the authors feel it necessary to issue a most emphatic warning against the indiscriminate use of gas masks for any and all purposes. The soldiers in the army have been taught that their gas mask will protect them absolutely against any gas the enemy may put up. These men, on returning to civil pursuits, carry this idea with them. They will not realize that the extremely poisonous gases used in warfare are chemically active, and, therefore, combine readily with the absorbents of the gas mask. Furthermore, outdoor gas concentrations seldom exceed a few hundredths of 1 per cent. Some of the gases which are successfully absorbed by the mask at these battlefield concentrations will immediately penetrate it when present in quantities of 1 or 2 per cent. In fact, the army gas mask is useless against many of the most common industrial gases, as for example, carbon monoxide, ammonia, natural gas, producer and blast-furnace gas, mine gases, coal and water gas, and probably any gas when occurring in concentrations exceeding five per cent.

In such cases the self-contained oxygen breathing apparatus must be used, as the gas mask does not supply any oxygen whatever.

In view of these serious limitations, the gas mask should be used only with the advice of an expert who has a thorough understanding of the limitations of this apparatus.

Pittsburgh Experiment Station,
Bureau of Mines,
Pittsburgh, Pa.

Flotation Experiments on Hardwood Tar Oils

By L. F. Hawley[1] and O. C. Ralston[2]

THIS PAPER describes a continuation of the work started by Palmer, Allen and Ralston* on the testing of various flotation oils prepared from wood distillation products, especially the more neglected hardwood products. The tests reported in the first paper indicated the very desirable characteristics of various crude wood distillation products as flotation oil. In continuing the tests, the object sought was to determine, if possible, the relation between composition and flotation properties, or the constituent or constituents responsible for the good quality. Although neither of these points was satisfactorily settled, considerable information of interest was obtained.

Samples 106 to 109 were all from the same wood distillation plant, and except for 107 were taken from regular plant products without special preparation. As was explained in the previous publication, the crude settled tar is commonly distilled with steam for the recovery of the acetic acid and wood alcohol which it contains; this produces two oily products—the "wood oil" distillate, which was previously found to be a very good flotation oil, and the residual heavy tar, which had never been tested. Sample 106 is this heavy tar and 108 is the wood oil for comparison. Sample 107 is the heavy oil obtained by distilling a tar like 106 until a temperature of 265 deg. C. is reached. Sample 109 is a commercial sample of dissolved tar, the residue obtained after distilling the crude pyroligneous acid. Sample 110 is another heavy tar like 106, but obtained from a different commercial plant.

[1]Chemist, Forest Products Laboratory.
[2]Formerly Metallurgist, Bureau of Mines.
*Trans., Am. Inst. Min. Eng., 1916, p. 1387.

Results of Comparison

A comparison of this series shows that the three crude tar products produced in the regular course of operation of most hardwood distillation plants, viz., "wood oil," "heavy tar" and dissolved tar, are all better flotation oils that the distilled heavy oil which can be obtained by further distilling the "heavy tar." The regular crude tar-products are all very good and very much alike.

Samples 113 and 114 were from the same plant as 110. They represent the oils which settle out in the crude alcohol storage tank and in the alcohol refining still respectively. No. 113 was a heavy oil with gravity 1.021, and No. 114 a light oil with gravity 0.931. Neither of these oils was as good as the tars and wood oils, but they gave results much the same as the distilled oil No. 107, which they resemble somewhat in composition. Sample 115 was a dissolved tar similar to 109 except that it was made from resinous wood (southern yellow pine lightwood) instead of hardwood. It is seen to be slightly inferior to the hardwood dissolved tar. This material is not of much interest commercially, since only very small quantities are produced.

Tests Made on Pitch

As already stated, the tests on samples 106 to 109 showed that the oil distilled from heavy tar was inferior to the heavy tar itself. This suggested that the pitch which is the other constituent of the heavy tar (heavy tar = pitch + heavy oil) might be the constituent largely responsible for flotation properties. A series of tests was carried out with samples of pitch dissolved in low-boiling redistilled wood oil (No. 144), acetone (No. 150) and carbon tetrachloride (No. 151), together with samples of the pure solvents for comparison. All of these tests showed that pitch dissolved in solvents of low flotation value added considerably to the flotation value of the solvent, but in no case gave an oil comparable with the tar from which the pitch was prepared.

The natural combination of pitch and volatile oils found in hardwood tar is therefore a better flotation oil than the volatile oils alone, or than the pitch dissolved in other volatile oils of lower flotation value.

Tests to Determine How Much Pitch Is Necessary to Give Maximum Flotation Value to a Hardwood Tar

Another series of samples, Nos. 141-144, was prepared for the purpose of determining how much pitch was necessary to give the maximum flotation value to a hardwood tar. The series consisted of end members of straight settled tar (about 40 per cent pitch) and distilled oil (no pitch), and intermediate members of one part tar to one part distillate (about 20 per cent pitch) and one part tar to two parts distillate (about 13 per cent pitch).

It is difficult to explain these results on a basis of pitch content, since the samples with 40 per cent pitch and the 13 per cent pitch seem to be about the same, and both better than the 20 per cent and zero pitch sam-

ples. It is very apparent, however, that the crude settled tar without any distillation treatment is a much better flotation oil than the distillate obtained from it up to a temperature of 260 deg. C., and as good an oil as can be obtained by mixing the distilled oil with the original tar. This conclusion corresponds well with that in regard to the relation between the heavy tar (tar from which light oils had been removed) and the oil which can be obtained from it by distillation (heavy oils only).

Removal of Alkali-Soluble Material Seems to Improve Oil for Flotation Purposes

Samples Nos. 146 and 147 were prepared and tested to settle a question which arose in connection with the operation of a plant producing distilled tar oil for a flotation oil. It was desired to extract part of the alkali-soluble material from a part of the distilled oil for use in manufacture of medicinal beechwood creosote, but it was not known what the effect of such partial extraction might be on the value of the residual oil for flotation purposes. Sample 146 was a straight distilled oil with boiling points 180-260 deg. C., while No. 147 was the same except that 40 per cent of the alkali-soluble material of the fraction 180-260 had been removed. The removal of this alkali-soluble material seems to have improved the value of the oil for flotation purposes, and this result indicates that the raw material for medicinal creosote can be removed from hardwood tar flotation oil without diminishing the value of the latter.

Commercial Tests Made

In order that the laboratory tests might be further checked, two of the promising oils were obtained in larger quantity and large samples sent to a number of prominent metallurgists in charge of representative plants with the request that they give them commercial full-scale tests in their mills, or semi-commercial tests in single units. The Anaconda Copper Co. tested the oils for both their copper and their zinc ores. The Bunker Hill and Sullivan tested the oils for their silver-lead ore, and a number of other operators did likewise. The oils did not meet with universal success in the treatment of all ores, but were found to be very satisfactory for some of them, and in a number of cases seemingly the full equivalent of the more expensive pine oils. The two oils tested were the commercial (hard-) wood oil (similar to No. 108) and the crude settled tar (like No. 141), both of which are produced in nearly all ordinary wood distillation plants, and whose recovery does not involve much special machinery.

Reports on Commercial Plant Tests

The following extracts from three reports on commercial plant tests indicate the results obtained more specifically:

A. "I am enclosing a report . . . on experiments with Nos. 1 and 2 hardwood oils. . . . It would seem that they are as effective on our ores[3] as steam distilled pine oil."

No. 1 is the same as No. 141 in Table I. No. 2 is the same as No. 108 in Table I.

B. "Both oils acted much the same on copper ore, but in the case of tests on zinc ore the tar did not give as good results as the oil. . . . These oils are worthy of consideration for use as flotation reagents. They would not give good results if used alone, but fair results should be obtained when used in conjunction with kerosene acid sludge."

C. "We have tested the sample of hardwood oil[4] which you recently supplied with the following results:

Date	Hours Run	Assay Concentrate Pb	Assay Concentrate Ag	Assay Tailings Pb	Assay Tailings Ag	Extraction Pb	Extraction Ag
14	20	44.9	24.5	1.21	0.60	84.0	83.6
15	24	49.2	26.2	1.28	0.60	82.5	83.1
16	24	48.2	25.8	2.21	1.00	69.1	71.5
17	24	52.5	26.5	1.52	0.70	78.9	80.2
18	24	51.4	25.2	1.40	0.70	80.7	80.3
19	24	45.9	23.1	0.98	0.40	86.8	89.1
20	12	47.2	24.8	0.70	trace	90.2	94.5
Average.....		48.4	25.3	1.38	0.63	81.1	85.0

Treatment in Regular Mill Operation

"This was in regular mill operation and no effort was made to get especially good results. We had considerable trouble feeding the oil, as our feeding devices are all of the drip type. This, of course, would be easy to remedy if we used this type of oil. The oil consumed over the period averaged 0.2 lb. per dry ton of feed. The results compare very favorably with those obtained from the use of pine oil and creosote."

TABLE I—RESULTS OF FLOTATION TESTS *

Sample No.	Description of Oil Used	Pb Per Cent in Concentrate	Pb Per Cent Extraction	Zn Per Cent in Concentrate	Zn Per Cent Extraction
106	Heavy tar	21.6	88.1	24.7	88.4
107	Oil, from 106 up to 265 deg. C.	24.8	85.5	18.3	66.6
108	Commercial "wood oil"	25.6	84.1	22.8	89.3
109	Dissolved tar	26.6	85.5	22.8	89.1
110	Heavy tar	19.0	92.3	18.9	87.4
113	Light oil from alcohol still	22.6	85.0	22.6	63.7
114	Heavy oil from alcohol still	20.9	73.8	20.2	67.0
115	Dissolved tar from pine wood	16.9	81.0	19.4	90.2
141	Crude settled tar	21.9	75.4	32.8	75.3
142	1 part 141 and 2 parts 144	24.5	78.8	32.3	61.5
143	1 part 141 and 1 part 144	22.8	67.0	32.8	54.5
144	Distillate from 141	26.6	59.8	30.8	33.5
146	Distillate 180-260 deg. C.	22.1	69.5	23.1	57.0
147	146 partly extracted with alkali	17.0	75.0	20.7	74.5
149	Pitch disolved in redistilled low-boiling wood oil	22.5	33.8	29.8	28.0
149B	Redistilled wood oil	24.3	31.2	37.4	23.7
150	Pitch dissolved in acetone	29.1	28.7	31.0	17.8
150B	Acetone	29.5	12.8	13.5	15.3
151	Pitch dissolved in carbon tetrachloride	29.5	59.5	32.5	19.0
151B	Carbon tetrachloride	31.4	32.8	12.2	0.0

*All the figures given in this table were obtained by tests in alkaline circuit. All the samples were tested also in acid and neutral circuit, but in most cases the results obtained with alkali were very much better, and the above figures are considered to give the best comparison of the different oils. As mentioned in our first paper, the tests were performed in a laboratory Janney flotation testing machine on a mixed zinc-lead sulphide ore.

Conclusions

We have found that some of the crude hardwood distillation products, as now prepared in many plants, are adapted to satisfactory flotation of a number of ores. An attempt to determine which constituents of the oils were of most value in flotation gave negative results, and it seems that the crude products are as a rule better than any of the fractions or refined products made from them. In other words, a *mixture* of different oils is more likely to do good flotation work than any one product alone. In spite of the fact that there is considerable prejudice against all resinous wood distillates which contain pitch, the statement being made that they spoil the "selection" of the oil and produce dirty flotation concentrate, we have not found hardwood pitch undesirable in most of the mixtures tested.

[3]The ore is a galena carrying silver.

[4]The same as No. 141 in Table I.

Determination of Uranium, Zirconium, Chromium, Vanadium and Aluminium in Steel—II

By Charles Morris Johnson

TO DETERMINE the amount of aluminium and zirconium in steel dissolve 4 g. of sample in 50 cc. of 1:3 H_2SO_4 diluted with 50 cc. of water. After action is over, filter off the insoluble residue, which is mainly carbides. Wash the carbides 25 times with dilute H_2SO_4 wash. Call this filtrate and washings *A*. The insoluble carbides will contain some Al and Zr. Ash the same in a platinum crucible at a low red heat. Cool; add 6 cc. HF plus 6 cc. of 1:3 H_2SO_4; evaporate to thick fumes; cool; add a little water, heat until all sulphates are in solution and add latter to *A*. Dilute *A* to about 250 cc. volume with water and add 1:1 ammonia with constant stirring until the first appearance of a black precipitate forms. Add a few drops in excess. At this stage all the zirconium and aluminium have been precipitated with a very small percentage of the iron. Filter off at once and redissolve precipitate in 50 cc. of hot 1:1 HCl. Wash the paper with dilute HCl wash till it looks perfectly white. Concentrate the filtrate and washings to about 50 cc. volume and peroxidize with sodium peroxide till the solution is alkaline. This peroxidization is carried out in the following manner: add from a small porcelain spoon about 1 g. at a time of Na_2O_2. Rinse off spoon into beaker with each addition of the peroxide and stir the solution each time, and so on until the solution is alkaline. By this process the volume reaches about 300 cc. by the time it is alkaline. Then add 5 g. of Na_2CO_3; bring it just to a boil and filter off the iron and zirconium. Wash precipitate with water about 25 times. The filtrate contains the aluminium. Redissolve the iron and zirconium in 50 cc. of hot 1:1 HCl and peroxidize again as before to remove the last traces of aluminium.

Add to the filtrate 1:1 HCl with constant stirring until turmeric paper does not change even to a faint brown when dipped in the solution, but red litmus paper gives an alkaline reaction. Keep cover on while adding the acid. Let aluminium settle for a few hours and after filtering it off, wash it about 40 times with ammonium nitrate wash. Redissolve the aluminium with hot 1:1 HCl, wash it with dilute HCl water. (Wash the papers also with water and burn off with the main precipitate, as some aluminium is liable to remain in the papers.)

To the filtrate and washings add 1:1 ammonia till slightly ammoniacal. Aluminium is precipitated. Now bring it to a boil, filter it off and wash it free of chloride. Burn it off in a weighed platinum crucible to a constant weight. Remove the silicon by evaporation with HF and a few drops of 1:3 H_2SO_4; again weigh as Al_2O_3. Multiply by 0.53033 to calculate to metallic aluminium.

Iron and Zirconium

The iron and zirconium on the filter are dissolved in 30 cc. of hot 1:3 H_2SO_4 diluted with 50 cc. of water. Wash the paper about 40 times with dilute sulphuric wash. Add to the filtrate 20 cc. of a saturated solution of Na_2HPO_4 (di-sodium phosphate); stir well. Add 1:1 ammonia slowly till a precipitate just starts to form. Zirconium phosphate comes down at this stage with very little iron, as the solution is still acid and most of the iron is in solution. The more zirconium with the sample the less ammonia it is necessary to add before a precipitate starts to form. After a few hours, preferably over night, filter off the zirconium phosphate plus some iron phosphate, plus some silicon. Wash the phosphate with water 40 times. Burn it off in a weighed platinum crucible. Add about 10 drops of conc. sulphuric acid and 10 cc. HF. Evaporate just to SO_3 fumes. Transfer the insoluble residue into a beaker. The iron phosphate will be in solution as iron sulphate, while the zirconium phosphate is insoluble. Warm the solution for a while to redissolve the iron sulphate that may be separated out. Filter off the insoluble residue, wash it about 50 times with water and burn it off in the same platinum crucible. (Some of the zirconium may stick to the crucible and cannot be transferred to the filter.) Burn it to a constant weight and weigh as zirconium phosphate, using the original weight of the crucible gotten just before the zirconium phosphate plus a little iron phosphate was burned in it. Multiply by 0.3838 to calculate to zirconium.

Standards were prepared by adding a known weight of metallic test aluminium and ZrO_2 (zirconium alba) to a plain steel: treated the same way as the samples. The recoveries are accurate. See table below.

TEST MIXTURES OF Fe, Al, and Zr

(1) Fuse ZrO_2 with potassium bisulphate, dissolve the melt in dilute sulphuric acid to get it in solution.
(2) Dissolve metallic aluminuim in 1:1 HCl; fume it with sulphuric acid. Dissolve in water to get it in solution.
(3) Pour (1) and (2) into the sulphuric acid solution of the drillings of the plain steel.

Recoveries	
Added	Found
0.015 g. aluminium	0.0164 g. aluminium
0.030 g. aluminium	0.0310 g. aluminium
0.050 g. aluminium	0.0495 g. aluminium
0.025 g. aluminium	0.0265 g. aluminium
0.0110 g. zirconium	0.0108 g. zirconium
0.0220 g. zirconium	0.0214 g. zirconium
0.0368 g. zirconium	0.0365 g. zirconium
0.0184 g. zirconium	0.0185 g. zirconium

Sample of so-called "zirconium steel" submitted to the author for analysis.
Sample A—Al, 0.41 per cent; Zr, 0.13 per cent; Si, 0.77 per cent.
Sample B—Al, 0.56 per cent; Zr, 0.17 per cent; Si, 0.75 per cent.

Aluminium in Plain Steel

Dissolve on a low flame 5 or 10 g. of steel in 50 cc. 1:3 H_2SO_4 diluted with 50 cc. of water. After action is over, filter off the insoluble residue, which is mainly carbon and carbides, wash it 25 times with dilute H_2SO_4 wash. Call this filtrate and washings *A*. The insoluble residue may contain Al, so it must be ashed in a platinum crucible at a low heat; cooled; 6 cc. of HF + 6 cc. of 1:3 sulphuric acid added; evaporated to thick fumes of SO_3; cooled; a little water added; heated to dissolve the sulphates, and the clear solution is added to *A*. Then dilute *A* to 250 cc. volume with water, and add slowly 1:1 ammonia with constant stirring, until the reddish precipitate changes to a blackish. All the aluminium is precipitated with but 3 or 4 per cent of the iron. Filter aluminium plus a little iron off at once; redissolve it in 50 cc. hot 1:1 HCl, pouring the acid back and forth until all the iron and aluminium is in solution. Wash the filter paper about 40 times with dilute HCl water. Peroxidize the filtrate with sodium peroxide until the solution changes red litmus paper to a blue. Add about 5 g. of sodium carbonate; bring it to a boil and filter off the iron. Wash the precipitate about 30 times with water.

If the pulp mixed with the precipitate is washed thoroughly no more aluminium will be left with the iron,

otherwise it is necessary to redissolve the iron in hot 1:1 HCl and make another peroxidation. To the filtrates add 1:1 HCl with constant stirring until turmeric paper does not change even to faintest brown when dipped into the solution, but red litmus paper turns slightly blue when dipped into it. Aluminium is precipitated at this stage. After a few hours, especially when aluminium per cent is low, filter off the precipitate and wash it about 40 times with ammonium nitrate, to remove the salts as far as possible. To free the aluminium from all sodium salts the aluminium is redissolved in 50 cc. hot 1:1 HCl. Wash filter 40 times with dilute HCl wash. (Wash the filter paper free of chloride with water and save it to burn with the main final precipitate, as aluminium is liable to remain in the filter.)

Precipitate the aluminium by adding 1:1 ammonia to the filtrate until faintly ammoniacal. Bring it to a boil and filter off the aluminium hydroxide. Wash it free of chloride with ammonium nitrate. Burn off in a weighed platinum crucible and blast it to a constant weight. Weigh it as Al_2O_3 plus SiO_2. Remove the silica by evaporation with a few drops of 1:3 H_2SO_4 and 10 cc. of HF. The remainder is Al_2O_3. Multiply by 0.53033 to calculate to aluminium.

ALUMINIUM RECOVERIES FROM STEEL

Weight of Steel Taken, G.	Aluminium Added, G.	Aluminium Found, G.
15	0.010	0.0102
10	0.020	0.0199
5	0.050	0.0508
5	0.030	0.0300
5	0.100	0.1005

Same weights of steel without any aluminium added were put through all of the foregoing operations and the blanks found were deducted from the above five samples.

Note: Dissolve the metallic aluminium in 1:1 HCl, fume it with 1:3 H_2SO_4; dissolve in water; add the aluminium sulphate solution to H_2SO_4 solution of the drillings, when making up standards, as metallic aluminium is only slightly soluble in 1:3 sulphuric acid,

Chromium and Vanadium

For determination of small amounts of chromium and vanadium, dissolve 5 to 10 g. of steel in 50 cc. 1:3 H_2SO_4, dilute with 50 cc. of water, using a 600 cc. beaker. After action is over, filter off the insoluble residue, wash it about 15 times with dilute sulphuric acid.

The insoluble residue is then washed off into the original beaker and held for further treatment to be described later. It will contain much or little of the Cr and V, depending on the total percentage of carbides present. The filter paper may still contain a little V and Cr in its pores. Ash it in a porcelain crucible; dissolve it in a few drops of conc. HCl with heat; fume with 5 cc. 1:1 H_2SO_4 to remove HCl. Add it to *A*.

Dilute the filtrate from the insoluble carbides at once to about 200 cc., and add 1:1 ammonia slowly with constant stirring till a black precipitate forms. At this stage, add drop by drop about 2 cc. of ammonia in excess to assure a complete precipitation of all the chromium and vanadium with very little iron.

Filter at once and redissolve in 50 cc. 1:3 H_2SO_4. Wash paper 25 times with dilute sulphuric acid wash. Pour filtrate and washings into the original beaker containing the insoluble residue (vol. at this point should not be more than 100 cc.). Heat beaker for a while and add 40 cc. of 1:20 HNO_3 to oxidize all carbides (*A*).

Continue to heat until any tungsten carbide present is yellow. By this time vanadium and chromium will be in solution, or if no tungsten is present, heat until all red fumes are gone and the residue is white and floating. Boil a few minutes and then add permanganate from a pipette a little at a time until a brown precipitate of manganese oxide forms that does not dissolve after 20 min. boiling. The boiling with permanganate brings the chromium and vanadium to their highest stage of oxidation.

Filter off the excess of manganese oxide together with some silicon and tungsten, if any is present. Use a heavy suction bottle and a porous crucible (zirconia crucible is preferred).

Wash the residue in the crucible about 15 times with water only. Transfer to clean beaker, volume about 300 cc. Finish as usual for chromium and vanadium with ferricyanide as an internal indicator. See the writer's method, "Rapid Methods for the Chemical Analysis of Special Steels, etc.," second edition, pages 7, 8, 9, 10, 11, 12 and 35-42.

The advantage of the method of course is to remove the bulk of iron, thus enabling the operator to take larger weights of sample. In this way a steel containing 0.01 to 0.02 per cent Cr or V, or both, can be analized with just as much accuracy as one containing 1 or 2 per cent Cr and 0.25 per cent V, or higher.

TABLE SHOWING RESULTS OBTAINED BY METHOD ON KNOWN STEELS

Steel Taken, Grams	Chromium Added, Per Cent	Results Found, Per Cent	Vanadium Added, Per Cent	Results Found, Per Cent	Blank, cc.
5	3.070	3.000	0.043	0.056	1.6
10	0.274	0.278	0.040	0.030	1.5
9	0.545	0.550	0.024	0.020	1.5
10	None	None	0.115	0.112	0.6
10	None	None	0.076	0.076	0.6
Cr-V-W steel 2 g	3.630	3.61	0.830	0.820	...
Cr-V steel 5 g	1.060	1.08	0.254	0.244	...
Cr-V steel 8 g	0.545	0.55	0.024	0.033	...
Cr-V steel 5 g	1.030	1.01	0.220	0.237	...
U. S. No. 30 std., 3 g.	1.370	1.37	0.215	0.220	...
Cr-V steel 5 g	1.060	1.05	0.228	0.228	...
24 Cr-V steel 5 g	1.060	1.03	0.140	0.142	...
Steel 2 g	None	None	1.913	1.879	0.3
Cr-V-W steel 2 g	2.750	2.72	3.190	3.230	...

Much credit is due to Mr. Max Engleman for the painstaking way in which the analyses were carried through to get the analytical proof given in the foregoing tables of recoveries for uranium, zirconium, aluminium, chromium and vanadium.

Copper, Nickel, Titanium and Tantalum

In all probability, the same scheme of precipitating the element away from the bulk of the ferrous iron by ammonia will answer equally well for the determination of large and small percentages of titanium and tantalum. Perhaps also for small amounts of copper and nickel. The author will make this a subject for later publication.

Crucible Steel Co. of America,
Pittsburgh, Pa.

Civil Service Examination

Oil Chemist (Male).—Salary $1200 to $1400. Duties will include the physical and chemical examination of hydrocarbon oils, fatty oils, oil residues, distillates, partial oxidation products and gases. File applications before June 24.

Temperature Observations on Heating, Quenching and Drawing of a Large Steel Forging

Determination of the Rate of Heating and Cooling of Large Masses of Steel—Arrangement of Thermocouples—Furnace and Forging Temperature Curves—Inverse Rate and Temperature-Seconds Curves

By O. A. KNIGHT* and F. F. HANSEN†

THE following experiment was conducted by the authors at the heat-treating plant of the Watertown Arsenal. An experiment closely approximating this one was carried out in the summer and fall of 1914 at the plant of the Midvale Steel Co. and is given in a report by Mr. M. E. Leeds in the *Proceedings* of the American Society for Testing Materials, Vol. XV, Part II, 1915, page 5. The results recorded in the present paper are, however, not in agreement with those reported by Mr. Leeds as regards the relation of temperature of forging to temperature of furnace.

The object of this investigation was to obtain accurate data on the rate of heating and cooling of large masses of steel. In addition to this it was desired to determine the relation existing between the temperature of the furnace and the temperature of the mass of steel on heating to, and holding at, the maximum temperature employed. The rate of cooling when the forging was oil quenched was also determined and the inverse rate cooling curve plotted.

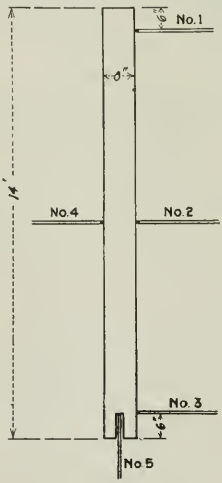
The inverse rate cooling curve, shown in this report, illustrates clearly that even with large masses of steel the critical transformation point is well defined. The heating curves show that the forging never attained the temperature of the furnace, but that on the contrary even though the temperature of the furnace was held constant for over an hour the temperature of the forging remained likewise constant, but was several degrees lower.

A study of the heating curves indicates that for any given temperature of furnace the maximum temperature to which the interior of the mass of steel will rise is soon established. The curves indicate that the higher the temperature the more nearly does the temperature of the steel coincide with that of the furnace. It is also shown that a large piece such as used in this experiment does not lose an appreciable amount of heat during a short interval of time in the air which must occur during the transfer of the piece from the furnace to the quenching bath.

The rate of cooling of a large piece when quenched in oil is far from being as rapid as is generally supposed. Thirteen minutes was required to cool the forging in question from 800 deg. to 300 deg. C. and 23 minutes to cool from 800 deg. to 200 deg. C.

The observations in this experiment were made on a forging 14 ft. in length by 8 in. in diameter. The forging was heated in a vertical oil-fired furnace, being handled and held in proper position by an overhead crane. Five base metal thermocouples were used in making the temperature measurements. All were carefully calibrated against a platinum standard before being used. One was placed near the top, two near the middle and one near the bottom of the forging with the hot junction of the couple in each case approximately 2 in. from the forging. These couples were protected by being properly insulated and enclosed in iron pipe. The fifth couple employed was inserted in the center of the lower end of the forging to a depth of 6 inches. The arrangement of the couples is shown in the accompanying sketch.

The long couple inserted in the lower end and used in determining the temperature of the forging was carefully insulated and after the hot junction was inserted to the proper depth it was carefully padded with asbestos felt and covered with sodium silicate (water glass) to exclude all furnace gases or oil which might otherwise influence the results. All of the couples were of the base metal type made from iron and constantin wire. The four used in determining the furnace temperature, i.e., placed near the surface of the forging, were connected to a Leeds & Northrup six-point recording potentiometer. The one inserted in the forging was connected to a portable potentiometer of the same make. With this arrangement for determining temperatures the data herein recorded may be taken to be accurate at least to a limit of 10 deg. C., since both the instruments and couples were carefully calibrated immediately before use.

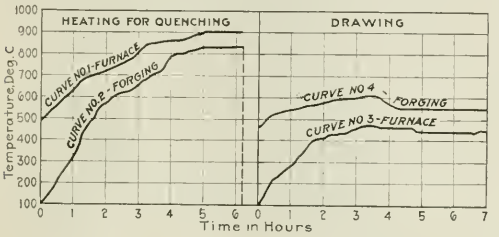


ARRANGEMENT OF COUPLES

The forging was gradually heated to 835 deg. C. and held approximately one hour at that temperature before quenching. The total time of heating was a little over six hours. After holding the forging at the temperature of 835 deg. C. for the desired time it was removed from the furnace and quenched in cottonseed oil. The total time expiring from the time the forging was withdrawn from the furnace to the time when it was quenched was 10 minutes. During this time in the air the piece cooled 8 deg. C. as measured by the couple inserted in the end.

*Asst. Metallurgist, Watertown Arsenal.
†Asst. Supt. Heat-treating Dept., Bethlehem Steel Co.

A study of the curves submitted with this report will bring out many points of interest. First, it will be noted at the beginning of operations, when the temperature of the furnace, as indicated by the average of the four couples near the surface of the forging, all of whose readings closely agreed, was 480 deg. C., that of the forging was only 100 deg. C. Curves No. 1 and No. 2 of the furnace and forging respectively are plotted

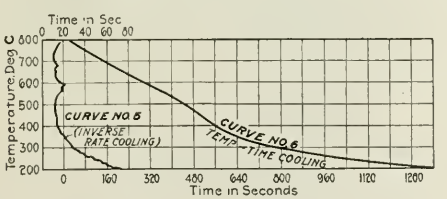


time as abscissa and temperature as ordinate. The temperature readings were taken every 10 minutes.

It will be noted that the temperature of the furnace was at no time attained by the forging, and the lower the temperature the greater the difference in temperature of furnace and forging. It will be further observed that holding the furnace temperature constant at 900 deg. C. for slightly over an hour imparted a uniform temperature of 835 deg. C. to the forging.

This is not at all in agreement with the data recorded by Mr. Leeds in his report previously referred to. The greatest difference he recorded between the temperature of the furnace and the center of the 12-in. specimen is shown in curve C, Fig. 5, of his report and is approximately 40 deg. F. at the end of a total heating of 7 hours.

Curves No. 3 and No. 4 show a similar relation between the temperature of the furnace and the temperature of the forging during the drawing operation. In the report by Mr. Leeds at the temperature of 1000 deg. F. (538 deg. C.) the temperature of forging



differs from that of the furnace by only a few degrees F. From curves No. 3 and No. 4 of the present report it is seen that while the temperature of the furnace is maintained constant at about 550 deg. C., the temperature of the forging is practically 100 deg. C. lower; thus a considerable difference exists in the two records taken. The curves submitted in the present report are plotted exactly from the data obtained without smoothing out any irregularities whatever.

Inverse rate and temperature-time curves plotted from the data obtained on cooling the forging in oil are also shown. It is to be noted that the rate of cooling is by no means as fast as commonly supposed to result from oil quenching. The transformation at the critical point on heating was so distinct that it could easily be detected while observing the electromotive force indicated by the couple. The temperature actually remained constant a short time at this point, which was 702 deg. C. The critical point on cooling is also quite plain in the inverse rate cooling curve. It occurred at 590 deg. C. as shown.

It is the hope of the authors of this brief paper to present at some future date more detailed data upon this subject, with the time of holding at the maximum temperature materially lengthened.

Metallic Coatings for Rust-Proofing Iron and Steel—III. Bibliography

By Henry S. Rawdon[1], M. A. Grossman[2] and A. N. Finn[3]

THE bibliography of the general subject of corrosion is extremely voluminous; probably more has been written on this subject than on any other phase of physical metallurgy. Many of the articles merely reiterate statements which have previously been published. Below is given a list of the most helpful contributions to the discussion of different phases of the subject as related to the rust-proofing of iron and steel by means of metallic coatings. The references to the literature throughout the text have been made by referring to the proper number in the first column:

Nature of Corrosion

1 1911 J. Newton Friend: The Corrosion of Iron and Steel. Longmans, Green & Co., New York.

2 1910 A. S. Cushman and H. A. Gardner: The Corrosion and Preservation of Iron and Steel. McGraw-Hill Co., New York.

3 1910 Alfred Sang: The Corrosion of Iron and Steel. McGraw-Hill Co., New York.

4 1917 Sir Robert Hadfield and Edgar Newberry: Corrosion and Electrical Properties of Steel. *Proc.* Royal Soc., Series A, 93, No. 647, p. 56.

5 1915 Frederick H. Fay: Protection of Metal Structures. *Proc.*, Eng. Soc. West. Penn., 31, p. 115. (Contains a very full bibliography.)

6 1915 The Corrosion of Metals: Ferrous and Non-Ferrous. A general discussion. *Journal* of Faraday Soc., 11, p. 183.
Sir Robert Hadfield: The Corrosion of Steel Alloys.
C. H. Desch: Physical and Mechanical Features in Corrosion.
J. N. Friend: The Relative Corrodibilities of Iron and Steel.
L. Aitchinson: Influences of Composition Upon the Corrosion of Steel.

7 1914 G. D. Bengough and R. M. Jones: The History of Corrosion. *Engineering*, 98, p. 489.

8 1913 William Vaubel: A New Chemical Cause for the Rusting of Iron. *Chem. Zeit.*, 37, p. 393.

9 1913 B. Lambert: An Electrolytic Theory of the Corrosion of Iron. Met. & Chem. Eng., 11, p. 272.

10 1913 Bureau of Standards Technologic Papers 18, 25, 26, 52, Electrolytic Corrosion of Iron in Soils.

11 1911 P. Longmuir: Corrosion of Metals. *Jour.*, I. and S. Inst., 83, p. 163.

Microstructure

12 1918 B. Durrer: Structure of Sprayed Metallic Coatings. *Metal Industry*, 16, p. 116.

13 1917 Hans Arnold: The Structure of Metallic Coatings Prepared by the Metallic Spraying Methods. *Zeit. anorg. allgem. Chemie*, 99, p. 67-72.

14 1915 Sieverts and Wipplemann: The Structure of Electrically Deposited Copper. *Zeit. anorg. Chemie*, 91, p. 1-44; also 93, p. 287.

[1]Associate Physicist (Metallography), Bureau of Standards.
[2]Metallographist, Vanadium Co. of America.
[3]Associate Chemist, Bureau of Standards.

15 1914 H. LeChatelier: The Alloys of Iron and Zinc. *Compt. rend.*, 159, p. 356.
16 1914 F. Taboury: The Alloys of Iron and Zinc. *Compt. rend.*, 159, p. 241-3.
17 1913 U. Raydt and G. Tammann: The Structure and Properties of Zinc-Iron Alloy Molten Under Pressure. *Zeit. anorg. Chemie*, 83, p. 257-66.
18 1912 W. Arthur and W. H. Walker: Structure of Galvanized Iron. Am. Inst. of Metals, 6, p. 82.
19 1912 Faust: The Structure, Recrystallization, and Properties of Electrolytic Copper. *Zeit. anorg. Chemie*, 78, p. 201.
20 1912 E. Vigouroux, F. Ducelliez, and A. Bourbon: Bull. Soc. Chem. de France, 4th ser., 11, p. 480.
21 1911 Wm. Guertler: Structure of Galvanized Iron. *Zeit. int. Metallographie*, 1, p. 353.
22 1910 T. Arnemann: The Microscopic Examination of Zinc. *Metallurgie*, 7, p. 201-211.
23 Hans Fleissner: Examination of Galvanized Wires. *Oesterr. Zeit. Berg-Hüttenw.*, 61, p. 379-84, 393-6.

Methods of Coating

1. Zinc.

Hot Galvanizing

24 1916 W. T. Flanders (and others): Galvanizing and Tinning. D. Williams Co., New York.
25 1918 G. A. White: A Metallurgical Study of the Steel Base as Related to Galvanizing. *Iron Age*, 101, p. 934. (Also enlarged into book form, Mathews-Northrup Works, Buffalo, New York).
26 1916 H. Altpeter: The Production of Metallic Coatings on Iron and Steel Wires, Especially Galvanizing and Tinning. *Stahl und Eisen*, 36, p. 741-9, 773-81.
27 1916 K. Arndt: The Galvanizing Process. *Zeit. angew. Chem.*, 29, III, p. 77, also *Journal*, Soc. Chem. Ind., 35, p. 362.

Sherardizing

28 1916 O. W. Storey: The Sherardizing Process. Met. & Chem. Eng., 16, p. 683.
29 1915 Samuel Trood: Sherardizing. Am. Inst. Metals, 9, p. 101.
30 1914 Samuel Trood: Theory and Practice of Sherardizing. *Iron Age*, 94, p. 91.
31 1914 General Facts About Sherardizing. General Electric Co. Bulletin, Y 694.
32 1912 A. R. Johnson and W. R. Woolrich: Zinc Cementizing. *Trans.*, Am. Electrochem. Soc., 21, p. 561.
33 1911 J. W. Hinchley: Some Practical Experience With the Sherardizing Process. *Trans.*, Faraday Soc., 6, p. 133.
34 1910 C. F. Burgess: *Sherardizing Magazine.*

Zinc Plating (Electrolytic Deposition)

35 1913 Georg Langbein: Electrodeposition of Metals. Trans. Wm. T. Brannt. H. C. Baird and Co., Philadelphia.
36 1916 O. P. Watts and P. L. De Verter: The Protection of Iron by Electroplating. *Trans.*, Am. Electrochem. Soc., 30, p. 1.
37 1918 William Blum: Military Applications of Electroplating. *Metal Industry*, 16, p. 498.
38 1912 William R. Barclay and C. H. Hainsworth: Electroplating. Edw. Arnold, pub'r., London.

Metal Spraying

39 1918 H. Arnold: Metal Spraying Process. *Metal Industry*, 12, p. 121.
40 1914 R. K. Morcom: Metal Spraying. *Engineering*, 98, p. 382.
41 1913 M. A. Schoop: The Production of Metallic Coatings. Met. & Chem. Eng., 9, p. 89.
42 1910 M. A. Schoop: A New Process for the Production of Metallic Coatings. Met. & Chem. Eng., 8, p. 404.

Epicassit Coatings

43 1918 Henry Hess: Coating Articles With Metals by Fusion. U. S. Patent 1,252,005.

2. Aluminium

44 1915 W. E. Ruder: Calorizing Metals. *Trans.*, Am. Electrochem. Soc., 27, p. 253; Met. & Chem. Eng., 13, p. 325.
45 S. Uyeno: Coating Iron with Aluminium. *Gas World*, 58, p. 490.

3. Copper, Nickel, Etc.

46 1919 J. W. Richards: Automatic Copper Plating. Bull. Am. Inst. Min. Eng., 145, p. 27.
47 1913 J. O. Handy: Copper Cover or Copper Clad Steel. *J. Ind. Eng. Chem.*, 5, p. 884.
48 Editor: Manufacture of Copper Clad Steel Products. *Metal Worker*, 78, p. 545.
Also 35 and 38.

4. Tin, Lead, Etc.

49 G. H. Jones: The Tinplate Industry with Special Reference to Its Relation With the Iron and Steel Industry. P. S. King, London.
50 1917 Structure of Coating or Tinned Copper in Relation to a Specific Case of Corrosion. Bureau of Standards Tech. Papers, 90.
51 1914 C. H. Procter: Tinning Articles of Brass, Bronze, Iron, and Steel. *Metal Industry*, 12, p. 64.
Also 24, 35 and 37.

Black Finishes and Similar Coatings

52 1910 Georg Buchner: Die Metallfärbung und deren Ausführung. M. Krayn, Berlin.
53 1918 E. S. Whittier: Black Finishes on Iron and Steel. *Metal Industry*, 16, p. 509.
54 1918 The Parker Rust-proofing Process. Met. & Chem. Eng., 18, p. 264.
55 1915 The Bontempi Rust-proofing Process. *Engineering*, 100, p. 602.
56 1911 E. Blassett: Coslettizing. *Metal Industry*, 9, p. 207.

"Pickling" and Its Effects

57 1917 T. S. Fuller: The Prevention of Brittleness in Electroplated Steel Springs. *Trans.*, Am. Electrochem. Soc., 32, p. 247. (Reviews the literature on the subject.)
58 1917 J. Coulson: Electrolytic Pickling Process and Its Effects on the Physical Properties. *Trans.*, Am. Electrochem. Soc., 32, p. 237.
59 1917 M. D. Thompson: The Electrolytic Pickling of Steel. *Trans.*, Am. Electrochem. Soc., 31, p. 51. Also Met. & Chem. Eng., 17, p. 713.
60 1915 J. N. Friend and C. W. Marshall: The Removal of Rust by Means of Chemical Reagents. *Jour.*, Iron and Steel Inst., 91, p. 357.
61 1915 O. Platts: Cleaning and Plating. *Trans.*, Am. Electrochem. Soc., 27, p. 141.
62 1914 E. A. Richardson: The Effects of Pickling Upon the Corrosion of Iron. Met. & Chem. Eng., 12, p. 759.
63 1913 W. Voss: Electric Cleaning of Metals. *Metal Industry*, 11, p. 510.
Also 11.

Methods of Testing Coatings

64 1916 F. N. Speller: Methods of Testing the Durability of Pipe under Corrosion. A. S. T. M. Proc., 16, II, p. 343.
65 1915 J. A. Aupperle: The Determination of Spelter Coatings on Sheets and Wire. A. S. T. M. Proc., 15, II, p. 119.
66 1914 J. A. Capp: A Rational Test for Protective Metallic Coatings. A. S. T. M. Proc., 14, II, p. 474.
67 1914 O. Bauer: Methods for Determining the Process and the Thickness of the Zinc Coating of Galvanized Iron Objects. *Mitt. kgl. Materialprufungsamt*, 32, p. 448.
68 1911 W. A. Patrick and W. A. Walker: A Method for Testing Galvanized Iron to Replace the Preece Process. *J. Ind. Eng. Chem.*, 3, p. 239.
69 1909 W. H. Walker: The Testing of Zinc Coated Metals. A. S. T. M. Proc., 9, p. 431.
70 1905 C. F. Burgess: Investigation of the Properties of Zinc Coatings. *Elec. Met. Ind.*, 3, p. 17.
71 1908 Tambou: Bull. Soc. Chim. de France. 4, pt. 1, p. 873.
72 1916 Com. A5. *Proc.* A. S. T. M., 17, pt. 1, p. 144.

Imports and Exports

The Bureau of Foreign and Domestic Commerce of the Department of Commerce reports for March, 1919:

DOMESTIC EXPORTS OF TIN PLATE, TERNEPLATE AND TAGGERS TIN FROM THE UNITED STATES TO ALL COUNTRIES

Countries	Lb.	Value	Countries	Lb.	Value
Denmark	1,036,300	$135,662	Argentina	8,497,017	752,759
France	61,227	4,985	Bolivia	167,134	18,744
Greece	72,105	9,479	Brazil	1,370,378	128,111
Norway	4,810,582	423,439	Chile	699,884	39,257
Spain	121,400	12,650	Colombia	1,002	102
Sweden	36,000	5,572	British Guiana	38,620	3,480
Switzerland	266,560	20,167	Paraguay	155,119	12,417
Canada	7,029,649	536,288	Peru	43,961	3,376
Costa Rica	10,904	989	Uruguay	6,866,302	553,164
Guatemala	13,726	1,710	Venezuela	9,500	1,035
Panama	4,080	1,585	China	2,750,281	226,103
Mexico	1,350,435	121,693	Japanese China	75,416	9,450
Jamaica	37,481	3,319	British India	1,436,910	108,056
Trinidad and Tobago	4,142	425	Straits Settlements	651,650	49,005
Other British West Indies (except Barbados)	900	165	Dutch East Indies	631,342	74,514
Cuba	144,064	11,774	Hongkong	479,584	44,549
Virgin Islands of U. S.	38	5	Japan	16,260,539	1,656,300
French West Indies	22,500	2,350	Australia	65	12
Haiti	500	48	British South Africa	1,000	225
			Egypt	347,680	24,882
			Total	55,505,977	$4,997,846

IMPORTS OF TIN BARS, BLOCKS, PIGS, OR GRAIN OR GRANULATED, INTO THE UNITED STATES FROM COUNTRIES AND DISTRICTS—TOTAL IMPORTS OF TIN ORE

	Tons	Value
Tin ore	1,066	$653,165

TIN BARS, BLOCKS, PIGS, GRAIN OR GRANULATED

Countries	Lb.	Value	Districts	Lb.	Value
Canada	282,318	$186,457	Pittsburgh	450,400	345,010
Straits Settlements	7,930,972	4,985,611	Maryland	56,092	36,361
Australia	71,680	45,395	San Francisco	3,153,263	1,847,098
			Washington	2,181,714	1,384,101
Total	8,284,970	$5,217,463	Dakota	224,167	144,250
			Wisconsin	112,000	76,882
Districts	Lb.	Value	Chicago	1,379,069	911,677
New York	616,083	$399,241	Total	8,284,970	$5,217,463
Philadelphia	112,182	72,843			

U. S. IMPORTS (TOTALS) OF GLYCERINE, AND EXPORTS BY COUNTRIES

Imports			Exports		
	Lb.	Value	Countries	Lb.	Value
Glycerine, crude			Dominican Republic	374	136
Exports			Argentina	53,720	14,977
Countries	Lb.	Value	Bolivia	250	64
Iceland and Faroe Islands	200	$60	Brazil	15,418	4,490
Norway	145,760	33,481	Chile	5,740	1,385
British Honduras	10	4	Colombia	2,286	1,072
Canada	1,330	246	Ecuador	250	95
Guatemala	718	450	French Guiana	30	10
Honduras	102	27	Venezuela	1,660	741
Nicaragua	88	24	Uruguay	112	53
Panama	20	6	China	3,371	786
Salvador	200	90	British India	20,700	7,632
Mexico	10,410	5,410	Dutch East Indies	12,300	3,244
Barbados	135	94	Hongkong	3,800	2,745
Other British West Indies (except Jamaica, Trinidad and Tobago)	20	16	Japan	104,867	25,268
Cuba	15,900	4,257	Siam	500	220
Dutch West Indies	252	65	Other Br. Oceania (except New Zealand)	52	41
Haiti	50	38	Philippine Islands	10	4
			British South Africa	65	22
			Total	6,245	2,127
				$406,945	$109,380

U. S. IMPORTS AND EXPORTS OF COPPER (TOTALS ONLY)

	Tons	Lb.	Value
Imports			
Ore	14,772	4,475,752	$894,342
Concentrates	8,700	2,229,506	396,395
Matte and regulus, coarse metal and cement	5,874	3,441,721	682,827
Manufactures of unrefined, black, blister and converter copper in bare, pigs or other forms		49,564,536	11,645,397
Refined copper in bars, plates, rods or other forms		1,678,919	367,857
Old and clippings for remanufacture		400,240	52,540
Composition metal, copper chief value		10,235	1,500
Exports			
Ore	29	1,600	300
Concentrates, matte and regulus			
Pigs, ingots, plates, wire, etc., unrefined black, blister and converter copper		269,343	90,120
Refined copper in ingots, bars or other forms		13,088,819	2,937,035
Composition metal, copper chief value		85,015	26,532
Old and scrap		219,036	34,424
Pipes and tubes		665,219	246,686
Plates and sheets		853,543	321,236
Wire, except insulated		12,039,554	3,423,090
All other manufactures of			709,093

IMPORTS INTO THE U. S. OF PLATINUM, IRIDIUM, OSMIUM, PALLADIUM, ETC., AND NATIVE COMBINATIONS THEREOF WITH PLATINUM, ETC.

Countries	Iridium, Osmium, Palladium, Etc. Native Combinations with Platinum Oz. Troy	Value	Unmanufactured Platinum Oz. Troy	Value	Ingots, Bars, Plates, Etc., of Platinum Oz. Troy	Value
France	745	$112,915	264	$32,083	..	.....
England	1,639	33,666	1,390	111,020	..	.....
Canada	70	4,856	.....	.....	16	$1,388
Panama	....	.....	261	22,185	..	.....
Colombia	....	.....	2,065	168,920	..	.....
Australia	17	1,897	.....	.....	..	.....
British South Africa	....	.....	.....	.....	7	660
Total	2,471	$153,334	3,980	$334,208	23	$2,048

Platinum—Vases, Retorts, Etc., None.

U. S. EXPORTS OF CAUSTIC SODA AND SODA ASH, BY COUNTRIES

Countries	Caustic Soda Lb.	Caustic Soda Value	Soda Ash Lb.	Soda Ash Value
Denmark	55,550	$2,750	.....	.....
France	4,033	950	.....	.....
Greece	241,600	10,214	.....	.....
Italy	112,000	14,318	.....	.....
Norway	699,571	53,171	22,400	$1,008
Sweden	474,663	17,390	1,008,220	51,638
Switzerland	73	29	.....	.....
England	380	50	.....	.....
British Honduras	1,545	76	.....	.....
Canada	502,050	20,036	3,131,787	69,220
Costa Rica	33,750	1,850	2,400	84
Guatemala	6,130	363	200	25
Honduras	25,580	924	.....	.....
Nicaragua	305	42	1,112	32
Panama	2,175	80	5,880	182
Salvador	5,300	270	.....	.....
Mexico	1,325,438	62,746	347,719	7,541
Newfoundland and Labrador	1,513	76	2,415	89
Jamaica	.....	.....	300	5
Other British West Indies (except Barbados, Trinidad and Tobago)	2,600	295	750	15
Cuba	495,505	16,264	96,730	1,748
Dominican Republic	26,075	864	.....	.....
Argentina	510,826	21,584	102,880	1,498
Brazil	595,409	36,426	374,955	18,169
Chile	102,930	4,522	30,000	570
Colombia	75,509	3,164	18,130	910
Ecuador	4,200	147	.....	.....
Peru	74,895	3,460	27,900	614
Uruguay	175,000	9,375	.....	.....
Venezuela	201,840	9,190	3,876	137
China	1,129,136	55,506	252,100	12,149
Japanese China	450	80	.....	.....
Chosen	450	80	.....	.....
British India	76,000	3,306	.....	.....
Dutch East Indies	1,302,582	86,833	358,390	15,833
Hongkong	218,325	13,238	.....	.....
Japan	3,085,109	151,645	2,707,135	84,946
Russia in Asia	114,090	9,180	.....	.....
Australia	34,160	1,066	4,480	145
Philippine Islands	164,162	9,554	.....	.....
British West Africa	325	8	.....	.....
Portuguese Africa	228	30	.....	.....
Total	11,881,462	$620,551	8,499,759	$266,558

DOMESTIC EXPORTS OF ZINC SPELTER AND OF ZINC ROLLED IN SHEETS, STRIPS, ETC., FROM THE U. S. TO ALL COUNTRIES

Countries	Zinc Spelter Cast In Pigs, Slabs, Etc. Produced from Domestic Ore Lb.	Value	Zinc Spelter, Cast in Slabs, Pigs, Etc. Produced from Foreign Ore Lb.	Value	Zinc Rolled in Sheets, Strips, Etc. Lb.	Value
Belgium	537,600	$40,320	.....	.....		
Denmark	6,724	650	.....	.....	10,691	$2,799
France	2,657,112	266,323	.....	.....		
Italy	3,351,896	226,253	560,040	$67,205	3,232,311	440,735
Norway	145,658	13,250	.....	.....	29,150	4,642
Spain	55,400	4,200	.....	.....		
England	6,984,049	573,400	1,080,215	93,601	273,992	37,226
Scotland	.....	.....	66,000	5,379	119,845	21,188
Canada	513,628	37,773	80,022	5,081	119,650	15,773
Costa Rica	.....	.....	.....	.....	638	119
Nicaragua	.....	.....	.....	.....	436	82
Salvador	.....	.....	.....	.....	154	31
Mexico	.....	.....	.....	.....	113,140	13,959
French West Indies	.....	.....	.....	.....	5,415	866
Argentina	.....	.....	.....	.....	90,187	16,056
Brazil	.....	.....	.....	.....	118,514	22,558
Chile	125	8	.....	.....	3,353	858
Colombia	.....	.....	.....	.....	6,713	1,052
Uruguay	.....	.....	.....	.....	2,700	650
Venezuela	.....	.....	.....	.....	2,500	427
China	.....	.....	.....	.....	32,119	5,432
British India	.....	.....	.....	.....	3,860	826
Dutch East Indies	9,000	900	.....	.....	72,713	11,502
Japan	112,000	9,862	.....	.....	76,813	13,519
Siam	.....	.....	.....	.....	41,122	7,284
Australia	.....	.....	.....	.....	13,108	3,238
Philippine Islands	.....	.....	.....	.....	2,284	341
British West Africa	.....	.....	.....	.....	271	82
British South Africa	.....	.....	.....	.....	996,436	141,659
Total	14,373,192	$1,172,939	1,786,277	$171,266	5,368,115	$762,904

Synopsis of Recent Chemical and Metallurgical Literature

Chemically Reactive Alloys.—E. A. ASHCROFT, in a paper recently read before the Faraday Society, described the properties of the binary system magnesium-lead. An alloy containing 15 per cent Mg when exposed to humid atmosphere will oxidize completely in a few hours to a jet-black powder, a mixture of hydrates and lead suboxide. This reaction can be used to remove the last traces of oxygen in a gas mixture or for the manufacture of small amounts of atmospheric nitrogen. Alloys with 35 per cent Mg rapidly decompose water at 150 deg. C. with the formation of metallic oxides and hydrogen, which reaction is very useful in aëronautics, requiring only a steam boiler and a readily transported alloy. The alloys are easily made by melting the primary metals under cover, or more preferably, by the electrolysis of fused anhydrous $MgCl_2$ over a cathode of molten lead.

Calcium-lead alloys act somewhat similarly, but not so rapidly. Zinc-magnesium in similar proportions, on the other hand, appears to be less readily oxidized than either component alone.

Corrosion of Condenser Tubes.—The fourth report of the Corrosion Committee of the Institute of Metals was presented in summary at the April, 1919, meeting, by G. D. BENGOUGH and O. F. HUDSON. Corrosion of zinc in distilled and sea water is regarded by the authors as being a process of chemical oxidation rather than electrochemical displacement, wherein H_2CO_3 locally dissolves the protective scale of oxide or basic carbonate existing on normal metal, baring a true metallic surface where a peculiar oxide—probably containing zinc peroxide—forms, which is slightly soluble, but is later precipitated as the ordinary hydroxide and carbonate, forming a protective coat.

Corrosion of pure copper is also chemical. A lower oxide (Cu_4O or Cu_2O) is formed on immersion which is protective but is slowly peroxidized into cupric hydroxide or basic carbonate. This in turn flakes off due to the formation of underlying bulky products: porous and amorphous oxides, slightly soluble. Pronounced local action does not occur.

When coupling electrodes of different metals the corrosion was often at variance to electrode potential lists, and the authors think that the effects of electrolytic corrosion have been over-emphasized, since sufficiently good contact is difficult to get. For instance, a metal may be oxidized and go into solution in spite of the fact that it is continuously cathodic.

Severe pitting of aluminium and some light alloys at the water line is shown to be due to the presence of strongly acid salt. Brass (70: 30) corrodes by solution of some zinc and a little copper in H_2CO_3, the remainder of both adhering as an oxide scale, becoming further oxidized locally and covered with thick porous deposits of the products of attack. Attack is accompanied by redeposition of copper, and is uniform in nature rather than a local dezincification. Pitting is due to accumulation of the products of corrosion, especially in sea-water.

A table (Table I) is presented of condenser tube troubles and remedies. In order that a tube may have a minimum life of 20 years, only clear water leaving no sediments should enter, this water to be neutral and free from gases in suspension or abnormal amounts in solution, not more than 35 deg. C. in temperature at the hottest region. Condenser water should travel about 5 or 6 ft. per second and the steam should be properly distributed. In practice quick failures are due to the fact that the normal slow roughening by chemical oxidation is locally accellerated by factors independent of the tube.

TABLE I—CAUSES OF CONDENSER TUBE AND FERRULE CORROSION. (WATER SIDE ONLY CONSIDERED)

Cause	How Produced	Nature of Action	How to Be Remedied
A. Foreign bodies carried in and accumulation of products.	A1. By ferric hydrate flakes from water ends. A2. By ashes, clinkers, etc. A3. By sludge of sorts in water supply.	Complete corrosion of the oxide disintegration type, causing local action.	A1. Paint the pipe line and water ends. Increase water speed. A1, A2, and A3. If worth while trap the water supply or pass it through a screen. In some cases increase water speed.
B. Acid or other bad or variable water supply.	B1. Some river supplies, *e.g.* Tyne. B2. Some canal supplies, *e.g.* ship canal. B3. Some well supplies. B4. Some estuarine supplies. B5. Some cooling tower arrangements.	Complete corrosion and rapid general thinning. Sometimes slight uniform dezincification.	Keep water supply slightly alkaline. Use special tubes adapted to the special conditions.
C. Temperature in condenser too high.	C1. Hot inlet water, *e.g.* tropical. C2. Slow water speed. C3. Partial blocking of tubes.	C1. Dezincification. C2. Dezincification. C3. See A3.	C1 and C2. Use special tubes. C2. Increase speed. C3. See A3.
D. Undue aëration.	D1. Errors in pump and pipe line arrangements. D2. Eddies near inlet causing water-line effect.	D1. Complete corrosion of oxide disintegration type. D2. Complete corrosion of pitted areas.	D1. Remedy air leaks, etc. D2. Special ferrules. Possibly increasing speed of water with modified design of water end.
E. Unsuitable composition of tube.	E1. Zinc or impurities in too great amount. E2. Surface of tube not sufficiently copper rich.	E1. Varies. E2. Dezincification.	E1. In manufacturing. E2. Probably by attention to details of annealing and pickling during manufacture.
F. Defective packing of tubes.	F1. Leaks caused by perishing of the packing material, especially in acid water. F2. Collapsing of tube.	F1. Varies. F2. Varies.	F1. Use good tape packing. Red lead is sometimes useful to prevent leakage. F2. Do not crush tube when inserting it.
G. Physically bad surface of tube; *e.g.* bad spills and laminations.	G1. Foreign bodies caught and trapped which would otherwise be swept away.	G1. Complete corrosion and oxide dezincification.	G1. During manufacture.
H. Thermo-electric action in condenser.	H. By steam impinging directly on tubes, or being improperly distributed.	H. Dezincification.	H1. Only occurs in condensers of old design when steam is not properly distributed.
I. Too slow water speed.	I. Gases given off inside tube and not immediately swept away.	I. Complete corrosion near inlet end.	I. Increase speed of water. Do not use main condenser for auxiliary machinery import.

Relation of Hardness to Tensile Tests.—Results of 114 tests on "smokeless-barrel steel" used in light Browning rapid-fire guns (C, 0.50 to 0.60 per cent; Mn, 1.15 to 1.30; Si, 0.18 to 0.25; P, 0.08 max.; S, 0.06 max.; ultimate 110,000; yield 75,000; reduction 40 per cent, elongation 20 per cent in 2 in.) are graphically tabulated by PROF. W. K. SHEPARD of Sheffield Scientific School in *American Machinist* for Apr. 17, 1919, p. 739. Inspection of the results shows that all specimens attaining the yield point had an ultimate strength of 115,000, while a reduction of 45 per cent would have agreed better with the 20 per cent elongation specification. Scleroscope tests fail to show any indication of low elongation, while the Brinell number between 255 and 269 shows a proper yield point and ductility. While the author does not advocate the replacement of tensile with hardness tests, he points out that inferior material can be easily located with a Brinell machine.

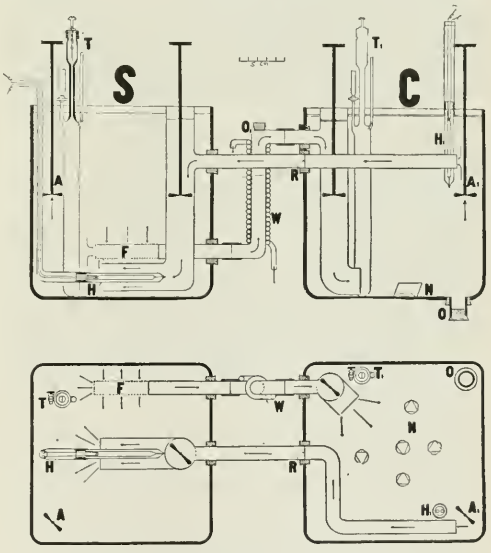
Tungsten in England.—JULIUS L. F. VOGEL, the metallurgist who founded the British tungsten industry, read a paper at the British Science Guild Exhibition on Aug. 30, 1918 (republished in the *Mining Magazine* for Jan., 1919), in which he reviewed the past and present situation of tungsten in England. He noted that Samuel Osborn & Co. of Sheffield made Mushet steel containing 6 to 8 per cent W for many years following its first use in 1857. The process consisted of reducing pure ore in a crucible of blister steel with an excess of carbon. F. W. Taylor's American researches caused an enormous advance in the use of high-speed steel, limited only by the gradual replacement of old machines insufficiently strong to take heavy, rapid cuts. Taylor and White's patents, by the way, were not upheld in England, and the larger production of high-tungsten alloys demanded a very pure alloying element, free from impurities omnipresent in wolfram (hubnerite, ferberite, etc.) such as Sn, Ca, As, S and P. At first a ferrotungsten of from 40 to 60 per cent was made in a crucible by carbon reduction, but the insistent demand for tungsten powder containing 95 per cent W and upward was met exclusively by the Germans, who were able to make 98 per cent metal with less than 0.5 per cent C. Hence grew the German monopoly of the European trade, despite several small-scale attempts in England to make tungsten powder.

On the declaration of war, England was left with a stock of but four months' normal consumption, and immediate conferences decided upon the stimulation of ore-production and local manufacture of high-grade tungsten powder. At the request of the Indian government a number of substantial Indian merchants took up and explored concessions in the recently opened Burmese districts. These men equipped mines and furnished transportation, resulting in largely increased production, but naturally at high cost. In many cases large sums were spent from which no return is likely.

English firms which collectively used some 80 per cent of the British consumption also immediately formed the High Speed Steel Alloys, Ltd., and by July, 1915, their factory at Widnes was delivering 98.5 per cent metal under the direction of the author. Their plant is substantially built, and is really but an enlarged laboratory. Fine ground ore is mixed with soda and fused, the cake crushed and boiled with water. Tungstate of soda goes into solution, while the insoluble basic oxides are filtered out. Pure tungstic acid (WO_3) is precipitated by HCl, filtered, dried, and reduced to metallic powder in special furnaces. Finally, the furnace product is washed and dried before packing.

Other companies have also entered this field, such as the Thermo-Electric Co., Blackwells, Continuous Reduction Co., British Thermit Co., Newcastle Alloys Co., Tyneside Alloys, and Albright & Wilson. Three of these use chemical processes similar to that at Widnes, two make ferrotungsten in an electric furnace, and three by aluminothermic methods. English makers of tool steels prefer the tungsten powder for its greater purity, although with pure ores, properly operated thermal processes will make a ferrotungsten which can be successfully employed in making high-speed steel.

Growth of Crystals.—The Feb. 19, 1919, issue of the *Journal* of the Washington Academy of Sciences contains an illustrated description of an apparatus used by J. C. HOSTETTER of the Geophysical Laboratory to form perfect crystals under controlled conditions for the study of strength, linear force of growing crystals, effects of non-uniform pressure on solubility, and effects of foreign substances in solution. While the apparatus has been used to study aqueous solutions, obvious modifications would permit the growth of substances of small solubility or from melts. The apparatus is shown in plan and elevation in the illustration, and consists essentially of two thermostats boxed together, the saturator *S* and the crystallizer *C*. By means of the thermostat *T* operating through relays the candle lamp *H*, *S* is maintained at a slightly higher temperature than *C* and is about ⅓ filled with large or bagged crystals. Saturated solution is drawn through gauze filter *F* into *C*, being directed against crystals *N*, placed on plane glass, and turned over daily. Volunteer crystals may be removed through *O*.



Perfect crystals require constancy in growth, which demands constant degree of supersaturation, constant temperature, uniform circulation, and a constant number of nuclei. The nuclei should be introduced at the start; they are small, well-formed crystals collected from a warm saturated solution allowed to cool overnight.

Recent Chemical and Metallurgical Patents

Buffer for Schoenherr Furnace.—JENS L. LA COUR, of Christiania, Norway, patents a buffer for nitrogen furnaces with long stable arcs under high gas pressure designed to minimize the effects of variations of gas pressure and velocity. It consists of a boiler (Fig. 1) mounted directly at the top of the tube-furnace *a*. Hot burned gases rising through *d* are partly cooled in the corrugated tube *c*, thence passing through the smaller tubes are drawn off the bottom of the casing. The steam pressure generated in this buffer-cooler is approximately equal to the gas pressure in the tube furnace, so that the metallic walls are under balanced forces. Such buffers may be placed in series, the first producing but a small decrease in temperature at the top of the flame tube in case the stability of the furnace action demands it. In any case, the buffer tube *c* being in line with the furnace *a* facilitates necessary variations in the end of the arc at *d* and equalizes pressure differences in the reaction chamber *a*. (1,296,194; assigned to Norsk Hydro-Elektrisk Kvaelstofaktieselskab, of Christiania, Norway, March 4, 1919.)

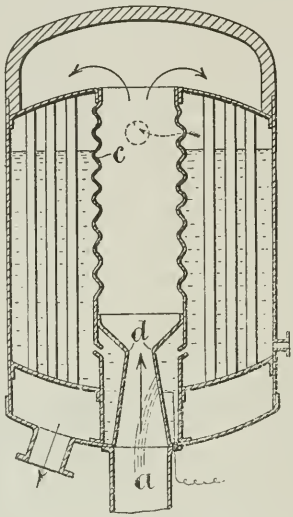


FIG. 1. BUFFER FOR NITROGEN FURNACE

Sulphonation of Aromatic Hydrocarbons

Aromatic Sulphonic Acids[1]—The counter-current principle has been applied to sulphonation by AMBLER and GIBBS. Sulphuric acid (sp.gr. 1.84), at a temperature above the boiling point of the hydrocarbon, flows down through a tower containing baffle plates, while vapors of the hydrocarbon are introduced at a point below the center of the tower. The process is continuous and, owing to the rapid removal of the sulphonated product, undesirable secondary transformations are practically eliminated. With toluene, monosulphonic acids are formed at 150 deg. C., while at 240-250 deg. C. the product is mainly toluenedisulphonic acid. (1,300,227 and 1,300,228; Apr. 8, 1919; dedicated to the public.)

Benzene Sulphonic Acids.—Benzene is passed into a still containing hot sulphuric acid (150-180 deg. C.) through a perforated ring below the surface of the acid. Unconverted vapors are condensed and returned to a storage tank. After a time, the speed of the reaction is greatly diminished, due to the dilution of the acid. When this point is reached (the ratio of free sulphuric acid to water in the mixture being 78 : 22) the system is evacuated by a suitable pump and the elimination of water vapor is facilitated by the stream of benzene vapor. By repeating these operations, a product containing over 90 per cent sulphonic acid and not more than 5 per cent free sulphuric acid may be obtained. This may be converted directly into the sodium salt without the necessity of first preparing the calcium salt. (1,301,360; ANDREW BENDER of Bogota, N. J., Apr. 22, 1919.)

Benzene Disulphonic Acid.—Another method for the production of sulphonic acids relatively free from excess sulphuric acid is described by CHARLES R. DOWNS of Cliffside, N. J. He has found that the mixture obtained by sulphonating hydrocarbons in the presence of excess sulphuric acid may be fractionally distilled under reduced pressure. With an absolute pressure of from one-half to one inch of mercury, water and free sulphuric acid may be removed from benzene disulphonic acid below 260 deg. C. without appreciable decomposition of the latter. Furthermore, during the distillation any monosulphonic acid present is converted into disulphonic acid, so that a very pure product is obtained. For the production of resorcinol this may be neutralized directly with soda ash, etc., and the solution added to the fusion pot without evaporating. (1,301,785; Apr. 22, 1919; assigned to The Barrett Co.)

Purification of Carbazol.—Commercial carbazol usually contains from 10 to 15 per cent of impurities (mainly anthracene), which yield sulphonic acids when treated with sulphuric acid even in the cold, whereas carbazol merely dissolves, provided the temperature is kept below 35 deg. C. The addition of water to the resulting solution precipitates carbazol which is 96 per cent pure and is almost entirely free from anthracene. By a single sublimation it gives substantially pure carbazol. (1,301,796; Apr. 22. 1919; JOHN M. WEISS of New York, assignor to The Barrett Co.)

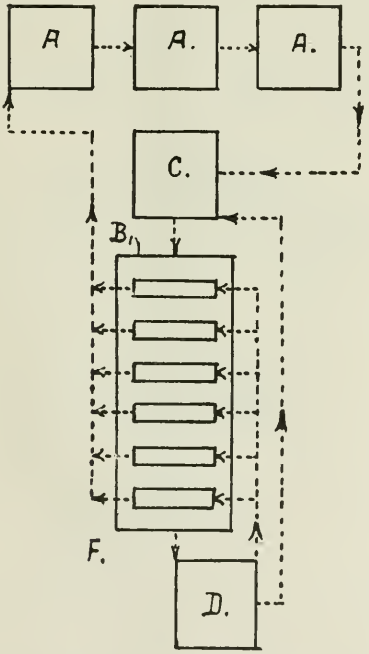
Iron for Precipitating Copper.—WOOLSEY MCA. JOHNSON of Hartford, Conn., suggests a method for preparing an efficient precipitation agent for the copper-bearing solutions in leaching processes. He transfers super-heated copper blast-furnace slag from an electrically heated settler into a long trough-like electric furnace. The reduction of iron oxide from such a slag is ordinarily slow, due to the fact that the surfaces in contact with the reducing agent are not sufficiently extensive to maintain a vigorous reaction. He, therefore, mixes the slag with pulverized coal by means of a number of jets of producer gas. The slag is thus progressively deoxidized as it passes along the long furnace, whose atmosphere at the same time is maintained sufficiently low in CO_2 that the electrode losses per ton of product will be moderate. As the slag flows toward the exit of this trough furnace and becomes lower in iron oxide, it comes in contact with a counter current of reduced iron having a lower and lower content of carbon and silicon. Thus metal quite low in these two elements may be tapped from the head end of the trough furnace, when it can be granulated or cast into such shapes as are desirable for use as a precipitating agent. The reduced iron oxide in the slag is replaced by hot quicklime, together with some fluorspar. (1,300,410; Apr. 15, 1919.)

[1] CHEM. & MET. ENG., Mar. 15, 1919, p. 282.

English Patents

Concentrating Ores.—In an agitation froth process for the preferential separation of one metalliferous mineral from another in a mixture containing them, for example a mixed sulphide ore, the agents employed are a soluble soap and sodium silicate in such proportions that a froth rich in one of the minerals is first obtained. After the froth has been separated the liquor may be diluted and re-agitated or aërated for the production of froth rich in another mineral. The ore is preferably treated in a freshly ground condition. (English Patent No. 121,303. E. EDSER, S. TUCKER and MINERALS SEPARATION, LTD., London, Eng., Feb. 5, 1919.)

Obtaining Metals Electrolytically With Circulating Electrolytes.—Granular Cu-Ni, Cu-Zn, or like alloys, obtained for instance by roasting and reducing matte, are treated with sulphuric acid, or other acid solution, until the acid is neutralized, and the solution is further treated with the same material to cement out the copper and produce a solution of nickel, zinc or the like for electrolysis. Mattes containing the two metals may be substituted for the alloy in the neutralizing



process. Air is introduced with the acid. From towers *A*, in which this treatment takes place, as shown in the illustration, the solution is run to a tank *C*, and thence to the cathode compartments of one or more electrolytic vats *B*. The solution is then conveyed to a tank *D*, whence most of it is returned to the supply tank *C*. The rest of this solution from the tank *D* is passed through the anode compartment *F*, the acid thus obtained being returned to the towers *A*. When two or more electrolytic vats are employed, the cathode compartments and the anode compartments may respectively be connected in series as regards liquid flow. Cathodes of iron and anodes of magnetite or hard lead may be used. The current density is 10 to 15 amp. per sq.ft. (English Patent No. 121,591. G. HAYLUND, Christiania, Norway. Not yet accepted. Feb. 12, 1919.)

Production of Ammonium Perchlorate and Sodium Bicarbonate.—Ammonium perchlorate is produced by reacting upon ammonium nitrate with sodium perchlorate in the presence of water. The precipitated ammonium perchlorate is separated and the solution of sodium nitrate is treated with ammonium bicarbonate or ammonia and carbon dioxide to cause the precipitation of sodium bicarbonate. The solution of ammonium nitrate after the removal of the bicarbonate is then used for reaction with a further quantity of sodium perchlorate. (English Patent No. 121,727—1918. D. AANENSEN, Christiania, Norway. Not yet accepted. Feb. 19, 1919.)

Acid-Proof Alloys.—Acid-proof alloys of iron and silicon containing not less than 13 to 15 per cent or more than 20 to 21 per cent silicon are made in a substantially pure state, preferably in an electric furnace. Pig iron may be melted with ferrosilicon and the impurities allowed to crystallize out of the molten mass, and a small amount of a flux, such as iron sulphide, may be added. Or iron or steel scrap may be melted with ferrosilicon, iron oxide being added when necessary to remove the carbon. The alloys may be used for making vessels for chemical manufactures and as anodes in electrolytic processes. (English Patent No. 121,730—1918. C. ROSSI, Legnano, Italy. Not yet accepted. Feb. 19, 1919.)

Reduction of Tungsten.—PETER ORANCE of New York City notes the difficulties inherent to properly mixing extraneous substances with tungsten oxides previous to their reduction, either by mechanical stirring of powders, by mixing into a paste, or by distillation of the body-material of a container. He proposes to obviate these by placing the tungsten oxide in a small closed shell capable of rotation, and during rocking of the vessel to blow into the mass heated air containing the addition agent, produced by volatilization from electrodes made of that material, by atomizing a solution, or by injecting a powdered material into the air blast. In this manner an intimate and uniform mixture may be had, which is then ready for molding into ingots prior to reduction, swaging and drawing, after the usual methods. (1,297,000; March 11, 1919.)

Improved Saggers.—F. J. TONE, of Niagara Falls, N. Y., has found that saggers or vats used to contain fine porcelains during firing are denser, stronger, more lasting and have a higher heat conductivity if containing a relatively high per cent of carborundum in addition to the usual clay grog plus plastic clay mixture. However, certain constituents of the clay or furnace gases alter the surface of the carborundum grains, which in turn produce a discoloration of the porcelain-ware contained in the sagger. The inventor finds that the action is confined to the surface of the grains, being limited to a thickness of from 0.0001 to 0.00001 cm., and therefore may be controlled by using relatively coarse carborundum (16 mesh) in moderate quantity—approximately 40 per cent of the mix. (1,296,715; asigned to Carborundum Co., March 11, 1919.)

Centrifugal Agitator and Distributor

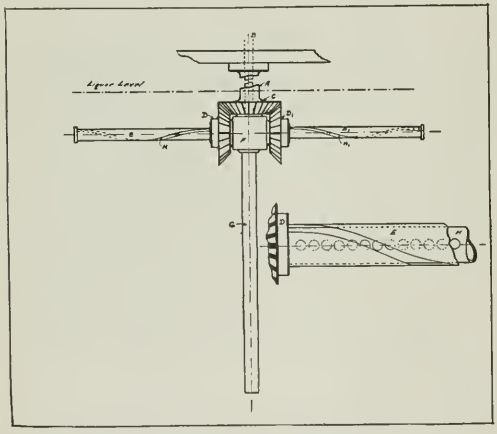
By Henry E. Jacoby

ONE of the simplest problems with which the manufacturing chemist has to contend, and at the same time one which often causes trouble and gives unsatisfactory results, is that of mechanical agitation. One reason for this is that so many operating men devise some crude homemade affair, putting a belt to it, and consider that all has been done that can be done in the way of getting satisfactory mechanical agitation.

The accompanying diagram shows the salient features of a device designed and patented by C. C. Thomas. One is immediately struck with not only the novelty of the mechanism, but also the basic principle which is applied. In general the device not only produces a mechanical stirring of the liquid or liquids in the containing vessel, the same as with the ordinary form of agitator, but at the same time produces a thorough vertical distribution of the material drawn to the vertex of the revolving liquid by means of a hollow vertical shaft.

The agitator is essentially a hollow tee which is supported by a suitable bridging or the cover of the tank, the upper part *A* being a hollow sleeve through which the vertical agitator shaft *B* passes. To the lower end of the sleeve *A* is attached a rigid bevel gear *C*, which meshes with the revolving gears *D* and D_1, the functions of which are to revolve the horizontal sleeve spiral distributors *E* and E_1 described below.

Part *F*, the head of the tee, is rigidly fixed to the solid agitator shaft *B* and revolves therewith. Attached to



MECHANICAL AGITATING DEVICE

the lower outlet of the tee is the vertical suction pipe *G*, and into each of the horizontal outlets are screwed the two horizontal arms *H* and H_1. These two horizontal arms *H* and H_1 are made up of wrought iron pipe perforated with a row of small holes for the liquid discharge. Sleeves *E* and E_1, which are rigidly attached to bevel gears *D* and D_1, are provided with a helical slot as shown in the diagram. The operation of the agitator is simple: The entire device being submerged in the liquid, the two horizontal arms *H* and H_1 are filled with the solution being agitated. As the device is revolved, no matter how slowly, there is sufficient centrifugal force developed in the arms to produce a flow of the solution in the arms toward the periphery. The solution so discharged is immediately replaced by liquid through the vertical suction pipe. The result is that even at very low speeds there is a circulation at once set up by liquid being forced from near the bottom of the containing vessel up and out through the revolving arms.

The function of the sleeves *E* and E_1 will not be apparent. As the agitator revolves, the bevel gears *D* and D_1, meshing with the rigid gear *C*, rotate. The result is that the helical slot in the sleeve will uncover successive discharge holes in the horizontal arms so that the point of the liquor discharge is continually traveling outward. The liquid is discharged at various points in a horizontal plane, and at continually varying distances from the center.

The results obtained by this device are really remarkable; not only is the distribution of the liquid beneficial, but the power required is remarkably small. It can readily be adapted to any existing tank, and will work successfully, not only on liquids of different densities, but will actually manipulate solid particles that are not too large to pass through the row of discharge apertures in the horizontal arms.

The apparatus has been tried out on a small scale for laboratory purposes, and has also been introduced into several manufacturing establishments, where it is giving excellent service. Its simplicity, as well as the excellent results obtained, should recommend it to all who have been on the lookout for an improved method of mechanical agitation.

Airtight Ashpit Door

CONSULTING engineers and architects are often required to draw detailed specifications for ashpit doors, because they have been unable to find a satisfactory standard piece of equipment. Contractors engaged in setting boilers are also often required to construct a steel door on the job because they had been unable to purchase a good door especially designed for the purpose.

The American Steam Conveyor Corporation, Chicago and New York, specializing in all forms of ash disposal, is manufacturing a door which has been produced as the result of careful tests and study, covering all points essential to successful operation and durability. It has been the experience of ash-disposal engineers that an ashpit door should be of ample size to allow easy removal of the ashes from the pit, but should not be unnecessarily large. If too large, it is impossible to keep the door from warping and thus leaking air, and it is also too heavy to be handled easily. A 24 x 36-in. door is ample for the largest pit, and this is the size recommended for ordinary use. Three other sizes of doors are also built of the same general design. These are in size, 18 x 18 in., 22 x 26 in. and 24 x 24 in.

The frame of the door is of cast iron of ample strength for all conditions, with the hinge and locking lugs cast on. The frame is of an angle design and sets well back into the setting. It is easily fastened into the pit wall by four bolts, one in each corner. The bearing surface is carefully machined. The hinge lugs are of ample strength to meet the hard usage to which these doors are subjected in operation.

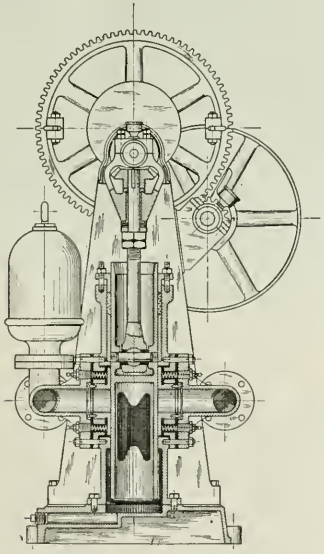
The door itself is of cast iron and is provided with a heavy ventilated cast-iron lining to prevent contact with the hot ashes and consequent warping. The bearing surface is carefully machined to make an airtight joint with the frame.

The hinges are of the floating type and two are provided. The hinge bars are pivoted to the frame and carry the door at the center where it is pivoted to the bars. This gives a perfectly distributed pressure over the door and keeps a tight joint at all points with no possibility of a clinker in the corner of the frame opening breaking or bending the door by a wedge action. It also allows the door to be swung entirely out of the operator's way.

Valveless Pump

THERE is no part of a pump exposed to greater wear than the rubber or other composition used in the valves on the water end. These valves, operating with every stroke of the pump, are not only subject to the continual pound as they open and close, but also have to stand the corrosive action of the fluid pumped. Different valves are required for different service—difference in pressure, difference in temperature of liquid, difference in nature of material pumped.

It is not easy to detect leaky pump valves, on account of their being closed, and a valve, after being in use a short time, may wear and suddenly break, putting a



SECTIONAL VIEW OF PUMP

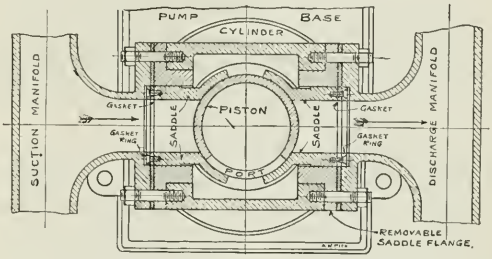
pump temporarily out of commission at a time when a shutdown for repairs means a considerable loss of time and money.

It might be said that the reputation of a pump depends more upon the quality and design of the valves than on any other part of the pump, because pump valves of a poor quality would seem to indicate poor material and workmanship in the pump itself.

Frequent failures of pump valves are often due to the fact that practically one class of pump valves are manufactured and sold for use in all kinds of service. Success under these conditions is practically impossible.

Further, all valves require for successful operation a special tension of valve springs, composition of rubber disc or metal seats. If these are not considered in the first place, the pump goes wrong, and the best pump is condemned as a failure. Tension of the spring is seldom adjusted evenly on all the valves, and those with the least tension are often to be the only ones that lift, thus defeating the object of multiple valves and greatly lessening the efficiency of the pump.

According to the best authorities, the friction of an ordinary check valve is equivalent to the frictional resistance of from 25 to 125 ft. of clear, straight iron pipe,



SECTIONAL PLAN THROUGH LINE OF SUCTION AND DISCHARGE, SHOWING SADDLES WITH PISTON AT END OF STROKE

varying according to the design, area of opening and tension of springs.

The renewal of valve parts is a continuous item of expense, and cannot be eliminated, unless you do away with valves. Ninety per cent of pump troubles are valve troubles. Ninety per cent of cost of upkeep of a pump is valve renewal cost.

Rotating Piston Pump

A new type of pump having a rotating hollow piston with a port simplifies the valve problem. The Dourte valveless pump, manufactured by the Mine & Smelter Supply Co. of Denver, has an exceptionally free passage for liquid into the cylinder when the suction is opened and a correspondingly free opening into the discharge, making it one of the best conveyors for liquids containing solids such as gravel, sand, sewage, pulp, coky pitches, etc.

The rotary movement of the piston is produced by a pair of miter gears one of which is keyed to the crank pin and the other to the end of the connecting rod. These gears are of equal size and number of teeth, therefore each complete revolution of the crank gives a corresponding revolution and stroke of the piston. With the crank at the extreme top or bottom, the piston is so placed that its port is not engaged with either suction or discharge opening, consequently all entries to the cylinder are closed.

On the upstroke the port in the piston is in connection with the suction opening, the discharge opening being closed or blanked by the wall of the piston. On the downstroke the situation is reversed, the port being in connection with the discharge opening while the suction opening is closed.

Referring to the illustrations, it will be noted that the piston is at the downstroke and the port neutral, being engaged with neither the suction nor discharge openings. As the piston rotates and advances upward spirally, the port engages with the suction or discharge openings, as the case may be.

The pump can be operated with equal efficiency in either direction, as reversing the direction of rotation

automatically reverses the flow of material through the pump. This feature is invaluable where it becomes necessary to clear the suction pipe, or where it is desirable to reverse the direction of flow, as in mixing tanks; thus the necessity of having a complicated arrangement of by-passes or a duplicate piping system is entirely eliminated.

The piston is a hollow casting open at both ends and is divided by a cross web near the center. The upper portion of the piston holds the connecting rod end by a universal joint, and the hollow receptacle here is of sufficient depth to contain the lubricant in which all the working parts are submerged, insuring perfect lubrication. The lower part of the piston contains a single port which alternately engages the suction and discharge openings on the side of the cylinder.

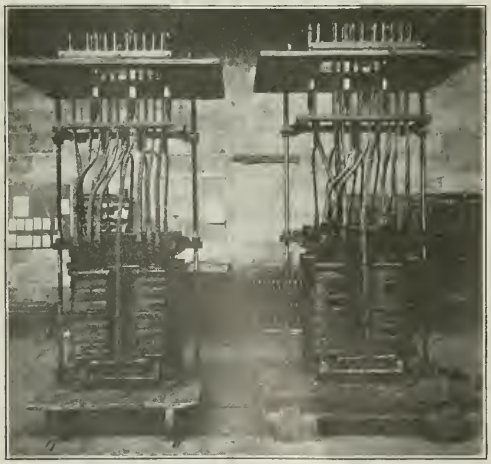
Transformers for Electric Furnaces

THE electric furnace owes its growing acceptance as a desirable medium both for heat-treating steel and melting non-ferrous metals chiefly to the more exacting control that it offers over furnace conditions. To supply an important link in the control equipment of its Baily electric furnaces, the Electric Furnace Co. of Alliance, Ohio, is building special transformers of the type illustrated.

These core type transformers are 400 k.v.a. capacity, and the high tension side, fitted with the usual voltage taps, is wound for 22,000 volts. The low tension side is fitted with ten special voltage taps to meet the particular voltage requirements of the furnace. Each transformer is single phase, and for small furnaces, requiring 100 kw. or less, one transformer is sufficient. Three-phase current is taken care of by two transformers fitted with a Scott connection. By means of the special low tension voltage taps, any desired current input may be delivered to the furnace through the selective oil break switches that are a part of each installation. With furnace current under control, any furnace temperature may be steadily maintained.

The transformers illustrated have just been shipped to the Braeburn Steel Co., Braeburn, Pa., as an accessory of a large 800-kw. continuous recuperative electric furnace that will be used to anneal alloy steel bars and wire. This special alloy requires a slow heating, lengthy soaking at maximum temperature, and cooling at a slow rate for the first 200 to 300 degrees.

This installation is of special interest, for although the usual annealing box covers are not used, scaling is entirely eliminated by this new method of electric annealing.

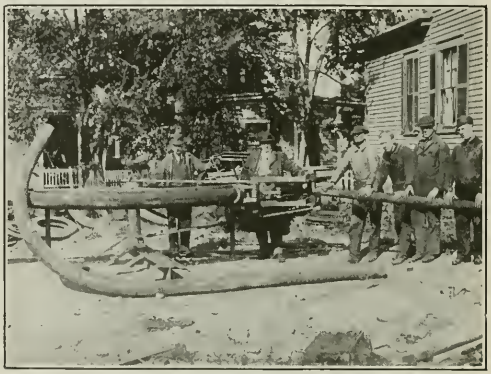


TRANSFORMER FOR ELECTRIC FURNACE

Pipe Bending Machine

SEVERAL models of portable pipe bending machines designed to handle from ⅜-1 in., ⅜-2 in., 1¼-4 in., and 3-8 in. pipe are manufactured by the American Pipe Bending Machine Co. of Boston. The machines are all of rigid construction, simply designed, and all parts interchangeable. An important feature is that they are all portable and may be knocked down and set up in a few moments.

A brief description of the machine will show its simplicity. The different machines have a central head suitably supported either for bench work, as with the Model S, or to be arranged with pipe legs in the larger models, A and B. On this head is mounted the interchangeable former-segments, and swiveled on the head is an arm on which is an adjustably mounted pin. On this pin is journaled a lever, on one end of which is swiveled a shoe of the proper size to fit the pipe to be formed. On the other end of the lever a pipe may be slipped to give sufficient leverage to bend the pipe, and the swinging arm is moved step by step as the pipe is bent, until the final bend is completed.



HERCULES PIPE BENDING MACHINE

The large model, or Hercules machine, is operated on a similar principle with improvements to give greatly increased power.

British Import Restrictions

The importation of the following commodities is prohibited except under special license:

Potassium salts, as follows: Bicarbonate, carbonate, chlorate, perchlorate, chloride (muriate), chromate and bichromate, cyanide, ferrocyanide (yellow prussiate), hydrate (caustic), nitrate, permanganate, sulphate, including potassium alums and potash manurial salts and mixtures containing any of these substances. Also saccharine and mixtures containing saccharine and other substances of like nature and use.

Pershing Commends Chemical Warfare Service

AMERICAN EXPEDITIONARY FORCES
Office of the Commander-in-Chief
March 2, 1919.

Col. Edward N. Johnston,
Chief of Chemical Warfare Service,
American E. F., Tours.

My dear Colonel Johnston:—Now that active operations have ceased and many of the personnel of the Chemical Warfare Service are returning to the United States, I desire to express to you and through you to all of your officers and enlisted men my appreciation of the valuable assistance they have rendered to the American Expeditionary Forces.

Upon our entry into the war we were faced with the problem of a new service in the organization of which the experience of our Allies was so new and so limited that there were few precedents to follow. The best brains and experience among our students and teachers of chemistry were called into service, and by rapid establishment of gas schools and the aid of specially trained personnel, all combat troops were instructed in the necessary defensive measures against poisonous gas. The first gas regiment was trained and equipped, and rendered good service in the two American offensives of St. Mihiel and the Meuse-Argonne.

Due to the energetic co-operation of all ranks, much was accomplished in a very short time, for which it gives me great pleasure to extend to you all the thanks of your comrades of the American Expeditionary Forces Will you convey this especially to Brigadier-General Fries, whose enthusiasm and energy were such great factors in the successful organization and development of the service.

Sincerely yours,
JOHN J. PERSHING.

Water-Resistant Glues

WATER-RESISTANT glues are of two general types, those made from blood albumen and those made from casein. All blood albumen glues are made directly from the raw ingredients at the time the glue is to be used. The manufacturers using these glues make them by their own secret formulas, and there are no published formulas available. Casein glues are made from casein, which is obtained from milk. They can be obtained in the prepared state ready for mixing with water, or they can be made directly from the ingredients at the time the glue is to be used.

The following prepared casein glues are now on the market: Certus glue, Certus Cold Glue Co., 88 Isabelle St., Detroit, Mich.; Napco glue, the Napco Corporation, Indianapolis, Ind.; Casco glue, Casein Mfg. Co., 15 Park Row, New York City, N. Y.; Perkins waterproof glue, Perkins Glue Co., Lansdale, Pa.

Directions for mixing the prepared glues can be obtained from the respective manufacturers or from the Forest Products Laboratory, Madison, Wis.

The water-resistant qualities of casein and blood glues are well demonstrated by the acceptance test imposed on plywood manufactured with these glues for use in aëroplanes. Samples of the plywood are boiled in water for 8 hours or soaked in cold water for 10 days. An acceptable product will show no separation of the plies under such treatment.

The shearing strength of casein and blood glues in plywood for aëroplane use is required to be at least 150 lb. per sq.in. Most of the plywood tested at the Forest Products Laboratory showed values considerably higher than this minimum requirement. In general, veneer panels glued with blood glue show higher average strength under the varying conditions than those glued with casein glues. It seems possible, however, that casein glues will in time be developed which will be the equal of blood albumen glues in this respect.

Both casein and blood glues are materially weaker wet than dry. Casein glues tested wet commonly have 20 to 40 per cent of their dry plywood shear strength, and blood glues 50 to 75 per cent. When plywood using these glues is redried after being soaked, however, the original strength of the glue is very largely recovered.

Blood glues are not at present commonly used for gluing anything thicker than veneer. Casein glues are used for gluing all thicknesses. Casein glue test joints, using blocks of maple with the grain running in the same direction, commonly have a shearing strength of 2000 to 2500 lb. per sq.in.

Blood albumen glue joints must be made with a "hot press" (having hollow plates heated with steam); a few minutes pressure is sufficient. Casein glue requires only an ordinary press, such as is used, with or without retaining clamps, for animal and vegetable glues.

The spreading equipment used for vegetable glues is suitable for both casein and blood albumen glues.

A mixer similar to the cake dough mixer used by bakers, consisting of a can in which a paddle revolves at high speed, is suitable for mixing casein glues. Blood albumen glues are mixed in different ways according to the requirements of their secret formulas.

Book Reviews

ELECTRO-ANALYSIS. By *Edgar F. Smith.* Sixth edition, revised, enlarged, 47 illustrations, xiii +344 pages, octavo. Philadelphia: P. Blakiston's Son & Co.

Analytical chemists and electrochemists in general owe Dr. Smith sincere appreciation of this careful revision of his indispensable book. Originally valuable because of containing the author's first-hand account of his contributions to this subject, the successive editions have grown, by careful condensation of the literature of the art, until it is a nearly complete handbook. Not only is the analytical chemist helped along, but the electroplater, the metal refiner, the electrometallurgist extracting metals from solutions, the electrochemist seeking new ways of coloring metals or of producing metallic compounds electrolytically, and yet other workers in electrolysis, can all find aid and comfort and generous assistance in studying its pages. The separation of the alkali metals in an improved "double cup" apparatus is an important item of novelty in this edition.

J. W. RICHARDS.

* * *

THE HYDROGENATION OF OILS, CATALYSIS, GENERATION OF HYDROGEN AND OXYGEN. By *Carleton Ellis, S.B.* Second Edition, thoroughly revised and enlarged, 767 pages, 240 illustrations. New York: D. Van Nostrand & Co.

The chemical and legal professions, at least those among them interested in the above subject, owe Carleton Ellis a debt of gratitude for his painstaking work in bringing together so many facts pertaining to the art of hydrogenation. He has succeeded remarkably well in giving the his-

tory of the subject from its beginning down to date, with descriptions of the very many processes described in patent and other literature, with full references, which makes the book exceedingly valuable to those interested in the patent side of the subject, while the very full accounts of the important litigations which have taken place add greatly to the interest from a legal standpoint.

The chapters on catalyzers are full of interest and present very fully in a compact form most all that has been written on the subject. The chapters on the uses of hydrogenated oils contain much valuable information, giving among other things a considerable insight into the lard-compound industry. A very useful chapter is the one on analytical constants, which presents in a compact form most everything which we have seen published. Those engaged in work on petroleum oils will find the chapter devoted to that subject very useful. The portion of the book describing the manufacture of hydrogen, covering 165 pages, would make a complete reference book by itself. The book taken as a whole is one which chemists and others connected with fat industries can hardly afford to be without.

DAVID WESSON.

* * *

COMMERCIAL OILS, Vegetable and Animal, With Special Reference to Oriental Oils. By *I. F. Laucks*. New York: John Wiley & Sons. 138 pages, inc. index.

This book, as stated in the preface, "is intended primarily for the non-technical man in the oil trade. The writer has attempted to give in it the technical data and information required in everyday dealings in the oil trade without mixing in a great mass of more or less scientific matter." The book contains trade rules and specifications wherever they may apply to the oils mentioned, besides giving conservative analytical constants. It is of particular value at this time, as it gives in a very compact form much information regarding various Oriental oils which are being imported at Pacific Coast points. There are tables showing properties of less common oils, together with comparison tables of hydrometers and thermometers. Last, but not least, is a very comprehensive index. DAVID WESSON.

Personal

DR. R. F. BACON, director of the Mellon Institute, is chairman of the committee of the American Institute of Chemical Engineers which is co-operating with the Government in the disposition of chemical plants and surplus stocks of chemicals and apparatus.

MR. H. FOSTER BAIN, who has served as assistant director of the Bureau of Mines through the war period, has resigned to resume exploration in the Far East. He sails from Vancouver June 12.

DR. JOHN S. BATES, who for several years has been superintendent of the Dominion Government Forest Products Laboratories in Montreal, Can., has resigned to take a position with Price Bros. & Co., of Quebec.

COL. G. A. BURRELL, Pittsburgh, Pa., has been given the degree of Doctor of Science by Wesleyan University, Middletown, Conn. Last year his alma mater, Ohio State University, gave him the honorary degree of Chemical Engineer.

MR. J. J. CADOT, recently returned from military duty in France, has accepted a position with the Hardinge Conical Mill Co., at the Denver, Colo., office.

MR. E. H. CLAUSSEN, recently discharged from military service, is with the Mine & Smelter Supply Co., at 42 Broadway, N. Y.

MR. THOMAS E. FISHER has resigned from the Wharton Steel Co. and become connected with the Traylor Engineering & Manufacturing Co. of Allentown, Pa.

GEN. GEORGE W. GOETHALS, best known as the builder of the Panama Canal, was presented with the John Fritz medal at the Engineering Societies Building, New York, on May 22.

MR. ELLWOOD HENDRICK, consulting editor of CHEMICAL & METALLURGICAL ENGINEERING, delivered the last lecture of a course before the Chemistry Club of the College of the City of New York on May 23, on "Some Chemists I Have Known." A large audience was present and listened to Mr. Hendrick's reminiscences and comments on Victor Meyer, Theodore W. Richards, Charles F. Chandler, Leo H. Baekeland and Irving Langmuir.

MR. R. W. HOVEY of the Forest Products Laboratories of Canada has resigned to accept a position with the Abitibi Power & Paper Co., at Iroquois Falls, Ont.

COL. DOUGLAS I. MCKAY has been elected president of the Pulverized Fuel Equipment Corp., New York, to succeed MR. JOHN E. MUHLFELD, who retires to return to consulting engineering practice.

MR. JOHN W. MALLER, until recently with W. R. Grace & Co., New York, has been appointed manager of the South American branch of the Ingersoll-Rand Co., with offices at Calle Merced 620, Lima, Peru.

MR. STUART B. MARSHALL, consulting engineer and metallurgist, has established his headquarters at Chevy Chase, Washington, D. C. He also retains his Roanoke, Va., address.

MR. CHARLES E. SHOLES has resigned from the Grasselli Chemical Co. to become vice-president and sales manager of the Edison Storage Battery Co. of Orange, N. J.

CAPT. EDWARD STEIDLE has recently returned from Europe to resume his work with the Carnegie Institute of Technology, Pittsburgh, Pa. He will devote his time to the development of a mining department which will be in close contact with the industry.

Current Market Reports

The Non-Ferrous Metal Market

Saturday, May 24. — Prices have tended to advance sharply with the prospects of an active market in sight.

Aluminium:—The open market is nominal at 33c. Sheets 18 gage and heavier, 42c. Powder, $0.70-$1.40 lb.

Antimony:—Antimony has advanced sharply with silver. Spot, 7⅞c. to 8⅛c. lb.

Copper:—An advance in price is now taking place with spot at 16½c. and futures higher.

Copper sheets, hot-rolled	lb.	$0.22½ —	.....
Copper sheets, cold rolled	lb.	.23½ —	.....
Copper bottoms	lb.	.23½ —	.....
Copper rods	lb.	.19½ —	.....
Copper wire	lb.	.17½ —	$0.18
High brass wire and sheets	lb.	.18½ —	.....
High brass rods	lb.	.17½ —	.....
Low brass wire and sheets	lb.	.18½ —	.....
Low brass rods	lb.	.21½ —	.....
Brazed brass tubing	lb.	.29½ —	.....
Brazed bronze tubing	lb.	.33½ —	.....
Seamless copper tubing	lb.	.28 —	.....
Seamless bronze tubing	lb.	.29½ —	.....
Seamless brass tubing	lb.	.30 —	.....
Bronze (gold) powder	lb.	1.00 —	.....

Lead:—Lead is rising. New York asks 5¼c. and East St. Louis 5c. lb. Sheet lead, 8c.

Tin:—Tin remains at 72½c.

Zinc:—Spelter has become firmer, advanced to 6.6c. to 6.75c. in New York and offers no low priced futures. East St. Louis quotes 6¼c. Zinc dust, 10c. Sheets, 12c.

OTHER METALS

Bismuth	lb.	$3.20 —	$3.65
Cadmium	lb.	1.40 —	.....
Cobalt	lb.	2.50 —	3.50
Magnesium	lb.	1.75 —	2.10
Mercury	75 lb.	92.00 —	.....
Nickel	lb.	.40 —	.45
Tungsten	lb.	Nominal	
Iridium	oz.	175.00 —	.....
Palladium	oz.	115.00 —	120.00
Platinum	oz.	105.00 —	.....
Silver	oz.	1.06½ —	.....

The Iron and Steel Market

Developments in the iron and steel trade are being watched with much more interest than their intrinsic importance would merit, because knowledge of trends is desired. Since the signing of the armistice and the termination of war work not one single thing has occurred

in the iron and steel market that would furnish of itself an accurate guide to the future. For instance, last December certain price reductions occurred, but that did not prove that other declines were to occur, at either regular or irregular intervals, and the same observations apply to the reductions that occurred in March. Each decline in the market occurred with a particular stage setting, but that was not significant.

The latest development in the steel situation is the increase in buying that began about the middle of May. In point of volume the increase is not of much importance. At some periods in steel market history such an improvement would be accepted as indicating a definite trend. The conclusion would be reached that business was improving, and further improvement would be awaited with confidence. In this case, however, the character of the buying is what must be scrutinized, rather than the quantity, and its relation to the old orders with which some producing interests were well fortified at the war's ending, and which have been gradually playing out, must be considered.

Character of the Buying

As to the character of buying, it is observed that it is the same as formerly obtained. The orders come from the same classes of buyers, jobbers and ordinary manufacturing consumers. There is little buying for strictly new construction purposes. The increased buying does not represent greater "confidence" in the market, for the buyers are making purchases, as formerly, only for immediate delivery, and even at that they frequently seek price guarantees, which as a rule they do not secure. The buyers are not stocking up. In some instances they may be enlarging their stocks, but not for the purpose of having larger stocks for the future; rather for the purpose of carrying on a larger volume of business at present. It may be that some increase in buying has been produced directly by the exhaustion of stocks carried at the end of the war. The country was not bare of steel then by any means.

The conclusion is that the common everyday needs of the people, in iron and steel, have increased in the past few weeks, and that new construction, on any large scale, has not commenced. As to the influence of the playing out of old orders, not enough time has elapsed to show what this increase in new buying means. The constantly decreasing steel production since the beginning of the year has been due to the gradual exhaustion of old orders. Month by month, for instance, the Steel Corporation's unfilled obligations have decreased, the losses being much greater than the new bookings, as shown by the fact that the loss each month has been much more than half the estimated shipments. The monthly report of steel ingot production has indicated steel mill operations, in proportion to rated capacity, as follows: January, 87 per cent; February, 85 per cent; March, 77 per cent; April, 65 per cent, and the indication has been that May would show about 55 per cent. Whether there is enough increase in new buying, in connection with this recent improvement, to counteract the influence of old orders being completed, is still to be disclosed.

New Construction

The construction firms and fabricating interests report that in the past few months they have figured upon large quantities of construction work, but practically no jobs of any magnitude have been authorized. The projects are not abandoned, simply deferred, and there is no definite information as to why the deferments have been made. The investors themselves would probably be unable to assign definite and clear-cut reasons, and they certainly could not make a precise statement as to the set of conditions under which, if developed, they would be willing to go ahead. The Bridge Builders' and Structural Society has reported lettings of fabricated steel jobs, in proportion to fabricating capacity, as follows: January, 12 per cent; February, 12½ per cent; March, 17½; April, 24½ per cent. Nothing more favorable can be said of these figures than that they show a trend in the right direction. The jobs let have all been small.

To engage the full capacity of the steel industry new construction in large volume is essential. More than half the steel normally passes into investment employment, and certainly no other alignment can be expected now, when steel making capacity is 40 per cent greater than in 1914.

Railroad Requirements

It is traditional in the steel trade that there cannot be a full demand for steel unless the railroads are active buyers. The proportion of the total steel produced that passes to the railroads has been overestimated for years, perhaps partly because of the survival of old concepts based on conditions in the 1880's, when there was so much new construction of railroads. As a rough generalization it may be suggested that for normal upkeep of railroads between 10 and 15 per cent of the total steel that can be made is required, while anything like an extensive program of railroad expansion and development would double the tonnage. Under the most favorable conditions the railroads might take 25 to 30 per cent of the total steel that could be produced. In the past it has been only when the railroads were taking large tonnages that the steel industry was really busy.

For the remainder of this year the railroads will require very little steel. Analysis of the 1918 rail production statistics indicated that the steam roads had about 1,400,000 tons for replacement purposes, and at the beginning of this year it is understood that there was about 1,200,000 tons due them on old orders. On May 23 the Railroad Administration placed orders for 200,000 tons of rails, this being the mouse that came forth when the labors of the Industrial Board were abandoned. The tonnages for last year and this are ample for necessary replacement purposes. The railroads could lay many hundreds of thousands of tons of rails in addition, slightly improving the permanent way, but that would be a luxury not to be thought of in present circumstances. As to other steel requirements, a careful canvass of the situation has recently been made, disclosing that by some redistribution of material the railroads can get along to the end of the year with little additional steel beyond what is in stock at one point or another, or on order, for car and locomotive repair and ordinary upkeep in other directions.

Prices

The steel producers show little disposition to depart from the prices that became effective March 21. They are educated to adhere to existing prices, whatever they may be, unless they can effect advances, for they have no means of making clear-cut reductions and adhering to the new prices with the same fidelity as they showed with the previous prices. As long as there is no definite prospect that a break in the market would result in filling the mills and thus paving the way for an advancing market again, the mills are likely to make every effort to maintain the present schedules. Whenever they become convinced that the time is ripe for the starting of a general buying movement they will probably let down the bars, since it is traditional that such buying movement can thrive only on an advancing market. If when the time comes the market will not advance from the existing level, it will be necessary to provide it with a level from which it will advance.

The Chemical Market

New York, May 28.

Most of the job lots which were dumped on the market as soon as the armistice was signed, together with the quantities of salvage goods offered by the Government, have been absorbed. Soon the manufacturers' influence should be felt in a strengthened market. Furthermore, with the Government inclined toward protection, manufacturers are encouraged to bend every effort to meet the foreign competition which will follow the signing of the peace terms.

Inquiries, both domestic and for export, appear to show some improvement. Instead of being mere requests for prices, the inquiries are beginning to have substance.

Although the quoted price on caustic soda has under-

gone no change a perceptible strengthening of the market is seen. This is attributed to the increased domestic consumption and the demand for export, which have exhausted the war stocks. Japan has been the heaviest buyer.

There is a good demand for acetic acid, much of it being sold for export. However, the large stocks held by producers do not seem to have been affected and this commodity remains weak.

Unrest has been generated in the potash market by the arrival last week of 4000 bags of raw potash salts from Alsace-Lorraine and by the anticipation of further shipments from there, together with probable shipments from Germany within a few months. However, it is believed in most quarters that the Government will take a hand in regulating Germany's shipments. One house reports a large shipment of caustic potash and potassium carbonate to Denmark.

Sodium bichromate is weak due to the reduction in cost of the raw material from which it is made. Sodium sulphide is active, South American demand being the reason. The manufacturers are still maintaining the price of 4⅜c. a lb. for it, but second hands are shading this to the export trade.

With the textile mills settling down to work again, there is a strong demand for oxalic acid. Largely to stimulate trade, formaldehyde has dropped to 20-21c. Increased commercial demand, together with the depletion of war stocks, has stiffened glycerine. The sale of a carload of dynamite glycerine at 20½c. caused a general advance to 21c. Oxide of tin remains lower in price owing to the low price levels of some of its substitutes.

Of particular interest is the proposed formation of a $15,000,000 export company to represent the leading chemical manufacturers of the country.

WAXES:—There is a good demand for waxes, particularly carnauba. Last week 4400 bags of carnauba were placed on the market, making a record stock. Yet in the face of this the price of carnauba rose. Paraffine waxes declined because of lessened demand and the fact that manufacturers, having large quantities on hand, desire to stimulate business. Japan wax is selling at a high mark owing to scarcity of spot stock and the high price of tallow, with which it is sympathetic.

COAL-TAR PRODUCTS:—No increased activity among any of the crudes is noted; intermediates, however, are beginning to pick up. From all quarters comes the report that both domestic and export inquiries are improving. The export phase is hampered by the inability to procure shipping space.

OILS:—Vegetable oils show great activity with rapidly advancing prices. The main factor is the heavy export demand caused by the dearth of fats in Europe. Demand for all the vegetable oils has depleted stocks, resulting in a speculative market. The top price has not been reached.

In spite of a decline in linseed oil, due to smallness of demand, it is predicted that the short supply of seed will soon cause prices to soar.

SHELLAC:—Stocks of shellac are the lowest they have ever been, while prices are the highest ever attained in the history of the trade. There are practically no spot stocks of any grade. Of TN, the shellac on which the price of all the other grades is based, none is to be had at any price. The same is true of the other grades, with the exception of orange, fine, super-fine and A.C. garnet. The supply of these is limited and will soon be exhausted. Consumers are willing to buy any grade and at any price.

In normal times the price of TN holds close to 38c. a lb., the highest being $0.638 in 1875, the lowest $0.088 in 1888. The present price is nominal, but the situation will improve as soon as an expected consignment from Calcutta arrives.

The present situation is due not to the scarcity in the supply of shellac in India, but rather to the policy followed by the consumers. They reasoned that with the embargoes imposed by the war and the dangers to shipping removed the market was certain to decline. The market did decline and the buying was for immediate needs only. At the same time, while buying continued on this basis, dealers did not care to assume the risk of carrying surplus stocks. Then the market began to rise due to scarcity of spot stocks with the result that consumers rushed into the market and dealers had not enough stock on hand to supply the sudden demand.

Chicago, May 24.

Trade conditions in chemical lines continue to register the improvement indicated the first part of this month. With second hand stocks becoming materially reduced and nearly all prices either showing a slight advance or remaining firm, the tendency of buyers is toward longer term buying. The stabilizing market has caused buyers to seem more satisfied with dealers' offerings, and reflects generally a much more satisfactory condition than obtained during the preceding four months.

Jobbers state that gross sales are larger for May than in the corresponding month last year, yet still under those of last fall. With collections good a decidedly optimistic tone is noted.

Heavy chemicals are having a very slow recovery, caustic soda and bleach still being weak, but soda ash in fair demand with the price firm. Few changes in acids are noted, demand more nearly approximating supply than in the recent past. Carbolic is finding a fairly ready sale at 9 cents.

No price differences have developed in coal-tar products, benzol standing at 25c. No particularly large contracts have been noted, sales of small lots being the feature of the market, the movement being sufficient to prevent any accumulation of overstock.

The previously noted good market in vegetable oils is still in effect, with every indication of long continued similar conditions. The recent destruction of the Douglas Starch Works at Cedar Rapids, Iowa, by an explosion which was fatal to a large number of men, involved the loss of quantities of corn oil, and is having an immediate effect of further stiffening prices in this entire line.

Naval stores and flotation oils continue in excellent demand. No appreciable price changes are noted.

St. Louis, Mo., May 26.

A decided improvement in most branches of the heavy chemical market at St. Louis is reported by producers and traders to have manifested itself within the last week or two. Sulphuric acid, especially, the key item of the heavy chemical market, was more sought for than at any time since the signing of the armistice, it is reported.

Both inquiries and actual sales are more frequent and of heavier volume now than for many weeks. The revival in trading in the acids has given a firmer tone to the chemical market generally. The business of the last week, well informed men say, represents no mere temporary spurt of buying, but an actual resumption of activities in certain industries that have been very quiet or at a standstill since the cessation of hostilities.

Sulphuric Acid: — Of 60 degrees, a large supply is on hand. Comparatively heavy sales are reported for the last fortnight at around $12.50 a ton; 66-deg. acid is quoted at $18 a ton.

Muriatic Acid:—A fair business is being done in this line, producers say, and inquiries are increasing; $22 a ton for 18-deg. is quoted.

Nitric Acid:—This branch of the market remains stationary; very little trading is in progress and the price remains unchanged at 9½c. per pound for 38-deg.

Zinc Chloride:—A very good demand for this chemical is apparent here. It seems that the Railroad Administration is giving the creosoting people a good deal of work and this is being reflected in an increased demand for zinc chloride. The prevailing quotation is 4½c. per pound.

Sodium Sulphate:—Salt cake is quoted at $20 a ton and is in better demand than for some time in the past.

Sodium Bisulphate:—Niter cake is quoted at $3 a ton, with no demand at present, as the glass-manufacturing season does not open until Aug. 15. It is expected, from the character of present inquiries for this item, that business will be resumed about July 1.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET MAY 28, 1919

Acetic anhydride	lb.	.54 —	.60
Acetone	lb.	.15 —	.15½
Acid, acetic, 28 per cent	cwt.	2.50 —	3.00
Acetic, 56 per cent	cwt.	5.50 —	6.00
Acetic, glacial, 99½ per cent, carboys	cwt.	12.00 —	14.00
Boric, crystals	lb.	.13½ —	.14½
Boric, powder	lb.	.13½ —	.14½
Hydrochloric, tech. 20 deg.	cwt.	1.50 —	3.00
Hydrofluoric, 52 deg.	lb.	.08 —	.09
Lactic, 44 per cent, tech.	lb.	.14 —	.17
Lactic, 22 per cent, tech.	lb.	.05 —	.06
Molybdic, C. P.	lb.	6.50 —	7.40
Nitric, 40 deg	lb.	.07 —	.08
Nitric, 42 deg	lb.	.07 —	.08
Oxalic, crystals	lb.	.23 —	.28
Phosphoric, Ortho, 50 per cent. solution	lb.	.07½ —	.10
Picric	lb.	.75 —	.85
Pyrogallic, resublimed	lb.	2.50 —	2.55
Sulphuric, 60 deg., tank cars	ton	11.00 —	13.00
Sulphuric, 60 deg., drums	ton	17.00 —	.....
Sulphuric, 60 deg., carboys	ton	20.00 —	.....
Sulphuric, 66 deg., tank cars	ton	16.00 —	18.00
Sulphuric, 66 deg., drums	ton	21.00 —	.....
Sulphuric, 66 deg., carboys	ton	25.00 —	.....
Sulphuric, fuming, 20 per cent. (oleum) tank cars	ton	20.00 —	22.00
Sulphuric, fuming, 20 per cent. (oleum) drums	ton	25.00 —	.....
Sulphuric, fuming, 20 per cent. (oleum) carboys	ton	30.00 —	.....
Tannic, U. S. P.	lb.	1.30 —	1.40
Tannic, (tech.)	lb.	.42 —	.60
Tartaric, crystals	lb.	.82 —	.85
Tungstic, per lb. of WO_3	lb.	1.25 —	1.50
Alcohol, Ethyl	gal.	4.00 —	4.85
Alcohol, Methyl	gal.	1.25 —	1.30
Alum, ammonia lump	lb.	.04 —	.05½
Alum, potash lump	lb.	.08½ —	.10
Alum, chrome lump	lb.	.15 —	.....
Aluminium sulphate, commercial	lb.	.01½ —	.03
Alumibium sulphate, iron free	lb.	.02½ —	.03
Aqua ammonia, 26 deg., carboys	lb.	.06½ —	.08
Ammonia, anhydrous, cylinders (100-150 lbs.)	lb.	.30 —	.....
Ammonium carbonate, powder	lb.	.12½ —	.13½
Ammonium chloride, granular (white sal ammoniac)	lb.	.13½ —	.14
Ammonium chloride, granular (gray sal ammoniac)	lb.	.13 —	.14
Ammonium nitrate	lb.	.17 —	.20
Ammonium sulphate	lb.	.05½ —	.06
Amyl acetate	gal.	3.50 —	3.75
Arsenic, oxide, lumps	lb.	.09 —	.09½
Arsenic, sulphide, powdered	lb.	.30 —	.32
Barium chloride	ton	80.00 —	90.00
Barium dioxide (peroxide)	lb.	.19 —	.24
Barium nitrate	lb.	.10 —	.11
Barium sulphate (precip.) (blanc fixe)	lb.	.01½ —	.03
Bleaching powder (see calcium hypochlorite)			
Blue Vitriol (see copper sulphate)			
Borax (see sodium borate)			
Brimstone (see sulphur, roll)			
Bromine	lb.	.40 —	.50
Calcium acetate	lb.	.04 —	.05
Calcium carbide	lb.	.05½ —	.06
Calcium chloride, fused, lump	ton	19.00 —	25.00
Calcium chlorids, granulated	lb.	.01¾ —	.02
Caluium hypochlorite, (bleaching powder)	cwt.	1.50 —	2.00
Calcium peroxide	lb.	1.50 —	1.70
Calcium phosphate, monobasic	lb.	.22 —	.23
Calcium sulphate, precipitated	lb.	.09 —	.09½
Carbon bisulphide	lb.	.05½ —	.06
Carbon tetrachloride, drums	lb.	.13 —	.14
Carbonyl chloride (phosgene)	lb.	.75 —	1.00
Caustic potash (see potassium hydroxide)			
Caustic soda (see sodium hydroxide)			
Chlorine, gas, liquid-cylinders, (100 lb.)	lb.	.05 —	.08
Cobalt oxide	lb.	1.60 —	1.65
Copperas (see iron sulphate)			
Copper carbonate, green precipitate	lb.	.28 —	.31
Copper cyanide	lb.	.65 —	.70
Copper sulphate, crystals	lb.	.07½ —	.08
Cream of tartar, (see potassium bitartrate)			
Epsom salt (see magnesium sulphate)			
Formaldehyde, 40 per cent	lb.	.20 —	.21
Glauber's salt (see sodium sulphate)			
Glycerine	lb.	.21 —	.23
Iodine, resublimed	lb.	4.25 —	4.30
Iron oxide, red	lb.	.06 —	.08
Iron sulphate (copperas)	cwt	1.00 —	1.75
Lead acetate, normal	lb.	.12½ —	.15
Lead arsenate (paste)	lb.	.15 —	.18
Lead nitrate, crystals	lb.	.85 —	.86½
Litharge	lb.	.09½ —	.10½
Lithium carbonate	lb.	1.50 —	.....
Magnesium carbonate, technical	lb.	.12 —	.14
Magnesium sulphate, U. S. P.	100 lb.	2.00 —	2.50
Magnesium sulphate, commercial	100 lb.	2.25 —	2.50
Nickel salt, double	lb.	.13 —	.15
Nickel salt, single	lb.	.11½ —	.14
Phosgene (see carbonyl chloride)			
Phosphorus, red	lb.	.75 —	.80
Phosphorus, yellow	lb.	.35 —	.37
Potassium bichromate	lb.	.29 —	.33
Potassium bitartrate, (cream of Tartar)	lb.	.52½ —	.55
Potassium bromide, granular	lb.	.49 —	.50
Potassium carbonate, U. S. P.	lb.	.65 —	.70
Potassium carbonate, crude	lb.	.11 —	.14
Potassium chlorate, crystals	lb.	.25 —	.31
Potassium cyanide, 98-99 per cent		Nominal	
Potassium hydroxide, (caustic potash)	lb.	.35 —	.45
Potassium iodide	lb.	3.30 —	3.40
Potassium nitrate	lb.	.19 —	.22
Potassium permanganate	lb.	.60 —	.75
Potassium prussiate, red	lb.	.80 —	.95
Potassium prussiate, yellow	lb.	.34 —	.45
Potassium sulphate	ton	225.00 —	.....
Rochelle salts (see sodium potas. tartrate)			
Salammoniac (see ammonium chloride)			
Sal soda (see sodium carbonate)			
Salt cake	ton	14.00 —	.....
Silver cyanide	oz.	1.19 —	.....
Silver nitrate	oz.	.68 —	.70
Soda ash, light	100 lb.	1.50 —	1.75
Soda ash, dense	100 lb.	1.85 —	2.00
Sodium acetate	lb.	.06½ —	.08
Sodium bicarbonate	100 lb.	2.35 —	2.50
Sodium bichromate	lb.	.09 —	.10
Sodium bisulphate, (nitre cake)	ton	3.00 —	10.00
Sodium bisulphite	lb.	.05 —	.07
Sodium borate, (borax)	lb.	.07½ —	.08
Sodium carbonate (sal soda)	100 lb.	1.50 —	1.60
Sodium chlorate	lb.	.15 —	.18
Sodium cyanide	lb.	.30 —	.31
Sodium fluoride	lb.	.14 —	.15
Sodium hydroxide, (caustic soda)	100 lb.	2.50 —	2.75
Sodium molybdate	lb.	2.50 —	.....
Sodium nitrate	100 lb.	4 07½ —	.....
Sodium nitrite	lb.	.11 —	.13
Sodium peroxide, powdered	lb.	.25 —	.30
Sodium phosphate, dibasic	lb.	.03½ —	.03½
Sodium potassium tartrate (Rochelle salts)	lb.	.43 —	.45½
Sodium prussiate, yellow	lb.	.16½ —	.20
Sodium silicate, solution (40 deg.)	lb.	.01½ —	.02½
Sodium silicate, solution, (60 deg.)	lb.	.02½ —	.04½
Sodium sulphate crystals, (Glauber's salts)	cwt.	1.25 —	1.50
Sodium sulphide, crystal, 60-62 per cent, (cone)	lb.	.04½ —	.05
Sodium sulphite, crystals	lb.	.03½ —	.04
Strontium nitrate, crystals	lb.	.25 —	.30
Sulphur chloride	lb.	.05 —	.05½
Sulphur, crude	ton	35.00 —	37.50
Sulphur dioxide, liquid, cylinders	lb.	.10 —	.12
Sulphur, (sublimed), flowers	100 lb.	3.05 —	3.60
Sulphur, roll, (brimstone)	100 lb.	2.70 —	3.65
Tin bichloride, (stennous)	lb.	.22½ —	.25
Tin oxide	lb.	.60 —	.....
Zinc carbonate, precipitate	lb.	.18 —	.20
Zinc chloride, gran	lb.	.13½ —	.14
Zinc cyanide	lb.	.49 —	.50
Zinc dust	lb.	.09 —	.11
Zinc oxide, dry American	lb.	.09½ —	.11½
Zinc sulphate	lb.	.03½ —	.04

Coal Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha nsphthol, crude	lb.	1.00 —	1.10
Alpha nsphthol, refined	lb.	1.40 —	1.50
Alpha nsphthylamine	lb.	.40 —	.50
Aniline oil, drums extra	lb.	.22 —	.24
Aniline salts	lb.	.28 —	.33
Anthracene, 80% in drume (100 lb.)	lb.	.90 —	1.00
Benzaldehyde (f.f.c.)	lb.	1.00 —	1.15
Benzidine, base	lb.	1.00 —	1.15
Benzidine, sulphate	lb.	.90 —	1.10
Benzoic acid, U. S. P.	lb.	1.00 —	1.10
Benzoate of soda, U. S. P.	lb.	.95 —	1.10
Benzol, pure, water-white, in drums (100 lb.)	gal.	.22 —	.27
Benzol, 90%, in drums (100 lb.)	gal.	.22 —	.27
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech	lb.	.25 —	.35
Beta naphthol benzoate	lb.	4 00 —	4 50
Beta naphthol, sublimed	lb.	.75 —	.80
Beta naphthol, tech	lb.	.45 —	.55
Beta naphthylamine, sublimed	lb.	2 25 —	2 35
Cresol, U. S. P., in drums (100 lb.)	lb.	.18 —	.....
Ortho-cresol, in drums (100 lb.)	lb.	.23 —	.25
Cresylic acid, 97-99%, straw color, in drums	gal.	1.00 —	1.02
Cresylic acid, 95-97%, dark, in drums	gal.	.90 —	.92
Cresylic acid, 50%, first quality, drums	gal.	.60 —	.....
Dichlorbenzol	lb.	.07 —	.10
Diethylaniline	lb.	1.75 —	2 25
Dimethylanilins	lb.	.50 —	.57
Dinitrobenzol	lb.	.25 —	.35
Dinitrochlorbenzol	lb.	.25 —	.28
Dinitronaphthaline	lb.	.45 —	.55
Dinitrotoluol	lb.	.38 —	.45
Dinitrophenol	lb.	.30 —	.32
Dip oil, 25% tar acids, car lots, in drums	gal.	.38 —	.46
Diphenylamine	lb	.70 —	.75
H-acid	lb.	1.90 —	2.25
Metaphenylenediamine	lb.	1.20 —	1.80
Monochlorbenzol	lb.	.13 —	.14
Monoethylaniline	lb.	1.50 —	1.75
Naphthaline, crushed in bbls. (250 lb.)	lb.	.06 —	.08
Naphthaline, flake	lb.	.07 —	.08
Naphthaline, balls	lb.	.10½ —	.11½
Naphthionic acid, crude	lb.	1.00 —	1.25
Nitrobenzol	lb.	.13 —	.15
Nitronaphthaline	lb.	.40 —	.45
Nitro-toluol	lb.	.17 —	.20
Ortho-amidophenol	lb.	6.00 —	.....
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	1.25 —	.....
Ortho-toluidine	lb.	.40 —	.45
Ortho-nitro-toluol	lb.	.35 —	.50
Paramsidophenol, base	lb.	2.75 —	3.50
Para-amidophenol, H. Cl.	lb.	3.00 —	3.25
Para-dichlor-benzol	lb.	.06 —	.10
Parasitraniline	lb.	1.10 —	1.25
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenedismine	lb.	3.00 —	3.25
Para toluidine	lb.	1.50 —	1.75
Phthalic anhydride	lb.	1.75 —	2.15
Phenol, U. S. P. drums (dest.), (240 lb.)	lb.	.08 —	09
Pyridin	gal.	$2.50 —	.....
Resorcin, technical	lb	3.50 —	3.75
Resorcin, pure	lb.	6.50 —	7.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.20 —	.30
Salicylic acid, U. S. P.	lb.	.25 —	.35
Salol	lb	.75 —	.85
Solvent naphths, water white, in drums, 100 gal.	gal.	.20 —	.25
Solvent naphtha, crude, heavy, in drums, 100 gal.	gal.	.18 —	.20
Sulphanilic acid, crude	lb.	.25 —	.30
Tolidine	lb.	2.15 —	2.50
Toluidine, mixed	lb.	.45 —	.80
Toluol, in tank cars	gal.	.22 —	.24
Toluol, in drums	gal.	.23 —	.30
Xylidine, drums, 100 gal	lb.	.40 —	.45
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	.....
Xylol, commercial, in drums, 100 gal	gal.	.30 —	.40
Xylol, commercial, in tank cars	gal.	.30 —	.....

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	.39 —	.40
Beeswax, refined, yellow	lb.	.44 —	.47
Beeswax, white pure	lb.	.62 —	.65
Carnauba, No. 1	lb.	.80 —	.83
Carnauba, No. 2, regular	lb.	.65 —	.72
Carnauba, No. 2, North Country	lb.	.50 —	.55
Carnauba, No. 3, North Country	lb.	.42 —	.44
Ceresin, yellow	lb.	.16 —	.18
Ceresin, white	lb.	.18 —	.20
Japan	lb.	.14 —	.18
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.07 —	.08
Paraffine waxes, crude scale, 117-119 m.p.	lb.	.07 —	.08
Paraffine waxes, crude scale, 124-126 m.p.	lb.	.07½ —	.08
Paraffine waxes, refined, 118-120 m.p.	lb.	.09 —	.09½
Paraffine waxes, refined, 123-125 m.p.	lb.	.09½ —	.10
Paraffine waxes, refined, 128-130 m.p.	lb.	.09½ —	.10½
Paraffine waxes, refined, 130-132 m.p.	lb.	.10½ —	.11
Paraffine waxes, refined, 133-135 m.p.	lb.	.11½ —	.12
Paraffine waxes, refined, 135-137 m.p.	lb.	.12½ —	.13
Stearic acid, single pressed	lb.	.18 —	.19
Stearic acid, double pressed	lb.	.19½ —	.21
Stearic acid, triple pressed	lb.	.22 —	.24
Spermaceti	lb.	.30 —	.32

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lbs.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.		$0.68
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.		.45
Pine tar oil, ref., sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.		.33
Pine tar oil, double ref., sp. gr. 0.965-0.990	gal.		.58
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.		.38
Turpentine, crude, sp. gr., 0.900-0.970	gal.		.61
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.		.24
Hardwood oil, f.o.b. Mich., sp. gr., 1.06-1.08	gal.		.24
Pinewood creosote, ref.	gal.		.48

Naval Stores

The following prices are F.o.b., New York, for carload lots.

Rosin B-D, bbl	280 lb.	$12.00 —	$12.55
Rosin E-I	280 lb.	12.70 —	12.75
Rosin K-N	280 lb.	14.05 —	14.25
Rosin W. G.-W. W	280 lb.	15.05 —	15.60
Wood rosin, bbl	280 lb.	12.25 —	.....
Spirits of Turpentine	gal.	.81½ —	.78½
Wood Turpentine, steam dist	gal.	.75 —	.....
Wood Turpentine, dest. dist	gal.	.69½ —	.....
Pine tar pitch, bbls	200 lb.	8.00 —	8.25
Tar, kiln burned, bbl. (500 lbs.)	bbl.	12.50 —	13.50
Retort tar, bbl	280 lb.	13.50 —	14.50
Rosin oil, first run	gal.	.68 —	.78
Rosin oil, second run	gal.	.70 —	.80
Rosin oil, third run	gal.	.82 —	.83
Rosin oil, fourth run	gal.	.85 —	.95

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½
70-72 deg., steel bbls. (85 lb.)	gal.	.31½
68-70 deg., steel bbls. (85 lb.)	gal.	.30½
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½

Oils

VEGETABLE

Unless otherwise noted, the following prices are f.o.b., New York.

Castor oil, No. 3, in bbls	lb.	$0.21 —	$0.23
Castor oil, AA, in bbls	lb.	.23 —	.24½
China wood oil, in bbls	lb.	.18 —	.21
Cocoanut oil, Ceylon grade, in bbls	lb.	.15½ —	.16
Cocoanut oil, Cochin grade, in bbls	lb.	.17 —	.18
Corn oil, crude, in bbls	lb.	.19½ —	.20
Cottonseed oil, crude (f.o.b. mill)	lb.	.17½ —	.17½
Cottonseed oil, summer yellow	lb.	.23 —	.25
Cottonseed oil, winter yellow	lb.	.24½ —	.25
Linseed oil, raw, car lots	gal.	1.56 —	1.58
Linseed oil, raw, tank cars	gal.	1.52 —	1.56
Linseed oil, boiled, car lots	gal.	1.58 —	1.60
Olive oil, commercial	gal.	2.10 —	2.25
Palm, Lagos	lb.	.15½ —	.18
Palm, bright red	lb.	.15 —	.16
Palm, Niger	lb.	.14 —	.15
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.19½ —	.22
Peanut oil, refined, in bbls	lb.	.22 —	.24
Rapeseed oil, refined, in bbls	gal.	1.50 —	1.55
Rapeseed oil, blown, in bbls	gal.	1.58 —	1.60
Soya bean oil (Manchurian), in bbls., N. Y.	lb.	.16½ —	.17
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.15 —	.16

FISH

Winter pressed Menhaden	gal.	$0.89
Yellow bleached Menhaden	gal.	.91
White bleached Menhaden	gal.	.93
Blown Menhaden	gal.	.99

Miscellaneous Materials

All Prices F.o.b., N. Y.

Barytes, domestic, white, floated	ton	$25.00 —	$36.00
Barytes, off color	ton	22.00 —	27.00
Blanc fixe, dry	lb.	.03½ —	.04½
Blanc fixe, pulp	ton	30.00 —	45.00
Casein	lb.	.16 —	.18
Chalk, English, extra light	lb.	.05 —	.07
Chalk, English, light	lb.	.04½ —	.06
Chalk, English, dense	lb.	.04 —	.05
China clay (Kaolin), imported, lump	ton	35.00 —	.....
China clay (Kaolin), imported, powdered	ton	60.00 —	.....
China clay (Kaolin), domestic, lump	ton	10.00 —	20.00
China clay (Kaolin), domestic, powdered	ton	25.00 —	40.00
Feldspar	ton	11.00 —	15.00
Fluorspar, acid grade, lump, f.o.b. mines	net ton	30.00 —	35.00
Fluorspar, acid grade, ground, f.o.b. mines	net ton	35.00 —	40.00
Fuller's earth, domestic, powdered	ton	30.00 —	40.00
Fuller's earth, imported, powdered	ton	..... —	.....
Pumice stone, imported	lb.	.03 —	.06
Pumice stone, domestic	lb.	.02½ —	.....
Shellac, TN	lb.	.60 —	.....
Shellac, D.C.	lb.	..... —	.....
Shellac, V. S. O.	lb.	..... —	.....
Shellac, Diamond I	lb.	..... —	.....
Shellac, orange, fine	lb.	.73 —	.....
Shellac, orange, superfine	lb.	.75 —	.....
Shellac, A.C. garnet	lb.	.63 —	.....
Shellac, bleached, bone dry	lb.	..... —	.....
Shellac, bleached, fresh ground	lb.	..... —	.....
Soapstone	ton	15.00 —	25.00
Talc, domestic	ton	16.00 —	60.00
Talc, imported	ton	55.00 —	60.00

Refractories

Following prices are f. o. b. works:

Chrome brick	net ton 90–100 at Chester, Penn.
Chrome cement	net ton 45–50 at Chester, Penn.
Clay brick, 1st quality fireclay	net ton 35–45 at Clearfield, Penn.
Clay brick, 2nd quality	net ton 30–35 at Clearfield, Penn.
Magnesite, dead burned	net ton 50–55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton 80–90 at Chester, Penn.
Silica brick	net ton 41–45 at Mt. Union, Penn.

Ferro-alloys

All prices f. o. b. works.

Ferro-carbon-titanium, 15–18%, f. o. b. Niagara Falls, N. Y.	net ton	$220.00 —	.....
Ferro-chrome, per lb. of Cr. contained, 6-8% carbon	lb.	.32 —	.40
Ferro-chrome, per lb. of Cr. contained, 2–4% carbon	lb.	.70 —	.....
Ferro-manganese, 70-80% Mn	gross ton	110.00 —	125.00
Spiegeleisen, 16-20% Mn	gross ton	40.00 —	50.00
Ferro-molybdenum, per lb. of Mo	lb.	2.50 —	3.00
Ferro-silicon, 50%	gross ton	90.00 —	115.00
Ferro-silicon, 75%	gross ton	150.00 —	175 00
Ferro-silicon, 10-15%	gross ton	45.00 —	60.00
Ferro-tungsten, 70-80%, per lb. of contained W	lb.	1.30 —	1.60
Ferro-uranium, 35-50%, of U	lb.	7.00 —	.....
Ferro-vanadium, 30-40%, per lb. of contained V	lb.	6.00 —	7.00

Resales and overstocks make above prices approximate.

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	$0.70	
Chrome ore, 48% and over	unit	1.00 —	$1.25
Coke, foundry, f.o.b. mines	net ton	4.50 —	5.00
Coke, furnace, f.o.b. mines	net ton	4.00 —	5.00
Petroleum coke, f.o.b. Atlantic seaboard	net ton	16.00 —	16.50
Fluorspar, gravel, f.o.b. mines	net ton	18.50 —	20.00
Manganese ore, 45% Mn and over	unit	.50 —	.85
Manganese ore, chemical (MnO_2)	gross ton	60.00 —	70.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75 —	.85
Tungsten, Scheelite, 60% WO_3 and over per unit of WO_3	unit	9.00 —	10.00
Tungsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.50 —	8.00
Uranium oxide, 96%	lb.	..... —	.....
Vanadium pentoxide, 99%	lb.	6.00 —	.....
Pyrites, foreign, lump	unit	.17 —	.....
Pyrites, foreign, fine	unit	.17 —	.....
Pyrites, domestic, fine	unit	.14 —	.....
Ilmenite, 50% TiO_2	net ton	30.00 —	.....
Rutile, 95% TiO_2	net ton	200.00 —	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	3.00 —	3.25

Resales and overstocks make above prices approximate.

Plant Materials and Supplies

In carload lots, New York, unless otherwise stated.

BUILDING MATERIALS

Portland cement, at dock, without bags	bbl.	$2.30
Lump lime, common, including container	300 bbl.	2.65
Common brick, at dock	M.	15.00
Hollow building tile, { At factory, Perth Amboy, N. J., } 8x12x12	M.	194.40
	M.	291.60
Yellow pine, 3x4 to 8x8, 20-24 ft. long	M.	39.00
Yellow pine, 3x4 to 8x8, 20-24 ft. long at Chicago	M.	38.50
Yellow pine, 3x4 to 8x8, 20-24 ft. long at St. Louis	M.	35.00
Roofings, tar felt (14 lb. per 100 sq.ft.)	ton	50.00
Roofings, tar pitch (in 400-lb. bbl.)	ton	19.00
Roofings, asphalt pitch	ton	30.00
Roofings, asphalt felt	ton	65.00
Roofings, slate-surfaced shingles, per roll of 108 sq.ft.		2.10
Roofings, slate-finished shingles, 100 sq.ft.		5.50
Linseed oil, raw in barrels	gal.	$1.63
Linseed oil, 5 gal. cans	gal.	1.76
Red lead, dry, 100 lb. keg	lb.	.13
Red lead, in oil, 100 lb. keg	lb.	.14½
Red lead, dry, 5 lb. cans	lb.	.15
Red lead, in oil, 5 lb. cans	lb.	.16½
White lead, dry and in oil, 100 lb. keg	lb.	.13
White lead, dry and in oil, 25 and 50 lb. kegs	lb.	.12½
White lead, dry and in oil, 5 lb. cans	lb.	.15

STRUCTURAL STEEL, MILL, PITTSBURGH

Beams and channels, 3 to 15-in.	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.66
Rivets, structural, ½-in. and larger	100 lb.	4.20
Rivets, conehead for boilers, ½-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.35
Sheets, No. 10 blue annealed	100 lb.	3.55
Sheets, No. 28 galvanized	100 lb.	5.70

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Alabama

ALBANY—The Southern Cotton Oil Co., First National Bank Bldg., Montgomery, plans to increase the capacity of its mixing plant to 10,000 tons and build a gin with 72-bale capacity near the oil mill here. Estimated cost, $50,000.

Arizona

PHOENIX—The city has had plans prepared by H. Phillips, consulting engineer, International Life Bldg., St. Louis, Mo., for a gravity water supply from the Verde River, to include filtration system, 42-in. pipe line and 25,000,000-gal. concrete reservoir. Estimated cost, $1,350,000.

TUCSON—Hereford & Hubbard plan to install a 100-ton concentration float mill on the Bannet property.

California

BISHOP—A. D. Schiveley, city clerk, will receive bids until June 2 for the construction of a sanitary sewerage system and sewage treatment tank. Olmsted & Gillelen, 1112 Hollingsworth Bldg., Los Angeles, engineers.

EMERYVILLE—The Sherwin Williams Co., 454 2nd St., San Francisco, will soon award the contract for the construction of a 2-story paint and varnish factory on the old race track, here.

HUNTINGTON BEACH—The city plans an election soon to vote on $40,000 bonds for rebuilding its gas plant. Olmsted & Gillelen, Hollingsworth Bldg., Los Angeles, engineers.

Connecticut

HARTFORD—The city has awarded the contract for the construction of a filtration plant, to the Foundation Co., 233 Broadway, New York City, N. Y. Estimated cost, $627,507. Noted Mar. 1.

Illinois

CHICAGO—J. McGillen, clerk sanitary district, Room 700, 910 South Michigan Ave., has awarded the contract for the construction of the Des Plaines River sewage treatment works, Division A, sewage treatment plant, to Leyden-Ortseifer Co., 53 Jackson Blvd., $384,281; Division P, electrical equipment, to the W. A. Jackson Co., 37 West Van Buren St., $22,795; Division W, venturi meters, to the Builders Iron Foundry, 209 South La Salle St., $12,760.

ROCKFORD—A. C. Woods & Co., engineers, plan to build a fabricating plant here.

Indiana

WHITING—The Board of Public Works will receive bids until June 2 for building a water system: (a) mechanical water-filtration plant, gravity type, 4,000,000-gal. per day capacity, including aërating basin, coagulating basin, filters, reservoir, head house; making connections with the city mains and the erection of equipment specified in (b); (b) one 5,000,000-gal. centrifugal pump, two 5,000,000-gal. centrifugal pumps, one 3,000,000-gal. centrifugal pump, two 3,000,000-gal. centrifugal pumps, one wash water pump, and one switchboard and equipment. Work under (a) includes 6,000 cu.yd. excavation and 440,000 lb. reinforcing steel. S. A. Greeley, 39 West Adams St., Chicago, Ill., engineer.

Iowa

ALTA—The city has awarded the contract for the construction of a sewage disposal plant, to Ward & Weighton, 516 Davidson Bldg., Sioux City. Estimated cost, $12,740.

AURELIA—C. H. Currie, engineer, Webster City, will receive bids until June 3 for the construction of a sanitary sewer and a sewage disposal plant. Estimated cost between $30,000 and $40,000.

GARNER—The city will receive bids until June 4 for the construction of a sanitary sewerage system and sewage disposal plant to include (a) disposal plant, tank, sand filters and sludge bed, (b) cutlet main sewer, (c) lateral sewers, J. G. Thorpe, 317 Howes Bldg., town engineer, R. V. Reed, town clerk

POCAHONTAS—The city will soon receive bids for the construction of a sanitary sewer, septic tank and beds in practically all the streets in the city. Estimated cost, $37,000. C. H. Currie, Webster City, engineer.

Maryland

HOMEWOOD (Baltimore, P. O.)—The trustees of Johns Hopkins University have awarded the contract for the construction of a 1-story, 50 x 150-ft. laboratory on Charles St. Ave., to Frainie Bros. & Haigley, 18 Clay St., Baltimore. Estimated cost, $55,000. Noted May 15.

WAGNERS POINT (Baltimore P. O.)—The Mexical Petroleum Co., 1015 Security Bldg., Los Angeles, Cal., plans to build an oil refinery here. Estimated cost, $1,000,000.

Massachusetts

CHICOPEE—The Torrington Manufacturing Co. plans to build an addition to its brass goods plant, here. Estimated cost, $50,000.

Michigan

PONTIAC—C. W. Ham, city clerk, City Hall, will receive bids until June 9 for the construction of sewage treatment works here. C. W. Hubbell, 2348 Penobscot Bldg., Detroit, consulting engineer.

Missouri

DUENWEG—The Log Cabin Mining Co. plans to move the Old Quaker Valley mill from Riverton, Kan., and erect same at Duenweg, and is in the market for a boiler, pump and tables. O. M. Long, manager.

SCOTLAND—The High Grade Zinc Mining Co., Duenweg, Mo., plans to build a new mill here and is in the market for a hoist, rock drills and small compressor. J. W. Baker, manager.

WACO—The Tulsa-Pittsburgh Mining Co., Pittsburgh, Kan., plans to build a mill at No. 2 shaft and is in the market for equipment for same. G. O'Connor, superintendent.

Nebraska

GENEVA—The city received bids for laying sanitary sewers and installing Imhoff tank and sprinkling filters, from S. A. Coneglia, Omaha, $30,225; A. A. Dobson Co., 945 D. St., Lincoln, $30,890; G. Vlasnik, 624 North 32nd St., Lincoln, $31,688.

North Dakota

GRAND FORKS—The State Board of Regents has awarded the contract for installing chemical tables for new chemistry building, at the University of North Dakota, to L. Peterson, 1234 Fullerton Ave., Chicago, Ill.

New Jersey

NEWARK—The Board of Freeholders of Essex County will soon receive bids for enlarging the sewage disposal plant at Overbrook. Estimated cost, $100,000. A. Reimer, county engineer.

TRENTON—The Atlas Tire & Rubber Co. has awarded the contract for the construction of a 1-story, 90 x 360 and 82 x 92-ft. rubber plant on Enterprise Ave., to J. H. Morris Co., 615 Broad St. Bank Bldg. Estimated cost, $250,000.

New York

POUGHKEEPSIE—The State Hospital Commission, Capitol, Albany, will receive bids until June 4 for altering and building additions to the water supply system at the Hudson River State Hospital here. Plans include the installation of additional filters, changing the water mains and building a reservoir. L. F. Pilcher, State Architect.

SYRACUSE—The city is having plans prepared for the construction of a modern rubbish incinerator, to be operated in connection with the new garbage disposal plant, to consist of sorting sheds and furnaces. Estimated cost, $100,000. H. C. Allen, city engineer.

WATERTOWN — The Northern Oil & Fuel Co., 469 Coffeen St., plans extensive additions to its plant; to include the installation of two 50,000-gal. oil and gasoline tanks and completely equipped testing laboratory for handling tests of gasoline, oils and greases. Address G. W. Lane, general manager.

Ohio

SALEM—The city has awarded the contract for the construction of additional filter beds, to the Jones Construction Co., Salem. Estimated cost, $30,800.

Oklahoma

MIAMI—T. L. Green, consulting engineer, would like to receive catalogs and prices on flush tank siphons, intermittent disposal plant siphons, sludge pumps and sewerage and water filtration equipment.

Oregon

SALEM—The Valley Packing Co. has awarded the contract for the construction of a meat packing plant, to F. J. Leonard, Lewis Bldg., Portland. Project includes a 24 x 36-ft. building for rendering tanks, boiler room and fertilizer department. Total estimated cost, $130,000.

Pennsylvania

ALLENTOWN—The city plans to build a sewage disposal plant on a 400-acre farm purchased three years ago, with a capacity sufficient to care for the entire city. It is planned to purify the sewage by a newly discovered process, which makes use of electricity and lime. Work may be done under the supervision of H. T. Bascombe, city engineer. Estimated cost, between $3,000,000 and $4,000,000.

BAKERTON (Elmora P. O.)—The Bakerton Water Co. has awarded the contract for the construction of a water system, to the Ambursen Construction Co., 61 Broadway, New York City, N. Y. Plans include a 30-ft. concrete dam, together with gate house, filters, etc.

BLAIRSVILLE—The Western State Hospital for Insane, Altoona, is having plans prepared by Crooks & Cooley, architects, Jones Law Bldg., Pittsburgh, for the construction of a hospital and group of institutional buildings near here, to include a sewage disposal plant, reservoir, nurses' home and morgue, etc. Total estimated cost, $2,000,000. G. S. Idell, 34 South 16th St., Philadelphia, consulting architect.

BOYERTOWN—The School Board has awarded the contract for the construction of a 2-story high school on 4th St. between Monroe and Madison Sts., to W. J. Elliott, Coatesville. Plans include the installation of an experimental laboratory. Total estimated cost, $115,000.

FRANKLIN—The city has purchased a site on Elk St. and plans to build a sewage disposal plant.

PITTSBURGH—The A. M. Byers Co., 235 Water St., plans to build a 36 x 72-ft. water treating and filtering plant. Estimated cost, $35,000.

South Dakota

EAU CLAIRE (Columbia P. O.)—The Town Council plans an election soon to vote on $40,000 bonds for the construction of a waterworks system, to include filters, pumping station, etc. W. C. McCreight, Union National Bank Bldg., Columbia, clerk.

Tennessee

CHATTANOOGA—The Calvert-Harrison Feature Picture Producing Co. has awarded the contract for the construction of a film factory and studio, to the M. K. Wilson Co., James Bldg. Estimated cost, $50,000.

Texas

CISCO—The city has awarded the contract for the construction of two filtering plants having a daily capacity of 700,000 gal. to the National Water Purifying Co., Dallas. Estimated cost, $25,000.

EAST WACO—The Arrow Refining Co. has purchased a site of 60 acres here and plans to build an oil refinery.

GARLAND—The Gulf Pipe Line Co. has purchased a site of 120 acres here and plans to build an oil refinery.

HOUSTON—The Columbian Refining Co. plans to build a refinery on the ship canal near here. Estimated cost, $500,000.

LAREDO—The Texas Gulf Refining & Pipe Line Co. plans to build an oil refinery on the Texas-Mexico border here. Estimated cost, $250,000.

SHERMAN—The Merchants & Farmers Refining Co. plans to build a refinery here. Estimated cost, $100,000.

Washington

VANCOUVER—The Daily Clay Products Co. is having plans repared for the construction of the first unit of its clay plant. Estimated cost, $50,000. A. H. Haley, Vancouver, architect.

West Virginia

CLARKSBURG — The Lafayette Glass Co. has awarded the contract for rebuilding its plant, to the Memphis Steel Construction Co., Magee Bldg., Pittsburgh, Pa. Estimated cost, $70,000. Noted May 15.

WESTON—The State Board of Control, Charleston, will receive bids until June 14 for the construction of sewage treatment works at the Weston State Hospital, here. Plans include sewage pumping station equipped with two electric motors, two centrifugal pumps and automatic control equipment, also a sewage sedimentation tank, sprinkling filter, sludge bed and chlorinating plant. J. S. Larkin, member.

British Columbia

CASSIDY — The Granby Consolidated Mining & Smelting Co., 718 Granville St., Vancouver, has awarded the contract for the construction of a washing plant here, to the Taylor Engineering Co., 850 Hastings St., W. Vancouver. Estimated cost, $150,000.

Ontario

WELLAND—The Imperial Oil Co., 56 Church St., Toronto, has purchased a site here and plans to build a plant. Estimated cost, $40,000.

Nova Scotia

SYDNEY—The Dominion Tar & Chemical Co. has awarded the contract for the construction of a still house, to the Sydney Foundry & Machine Co., Sydney. Estimated cost, $30,000.

Quebec

GRAND MERE—The Laurentide Co., Ltd., McGibbon St. and 3rd Ave., manufacturer of paper, is receiving bids for the construction of a finishing room. Estimated cost, $30,000. D. Wurtile, c/o owner, engineer.

Coming Meetings and Events

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its Summer meeting at Boston, Mass., June 18-21. A symposium is planned on electric furnaces.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its 22nd annual meeting at Atlantic City, N. J., June 24-27. The headquarters will be at the Hotel Traymore.

THE AMERICAN ZINC INSTITUTE will hold its annual meeting at St. Louis, Mo., June 9-10.

THE FRANKLIN INSTITUTE will hold a meeting on May 21 at which the presentation of the Franklin Medal to Major-General James Douglas McLachlan on behalf of his Britannic Majesty's Government for Sir James Dewar will be given, together with the presentation of the Franklin Medal to Major-General George Owen Squier of the United States Army.

THE INTERALLIED CHEMICAL CONFEDERATION will hold its next meeting in London, July 15-18, 1919.

THE NATIONAL FERTILIZER ASSOCIATION will hold its 26th annual convention the week of June 23 at the Hotel Griswold, Eastern Point, New London, Conn.

THE NEW JERSEY CHEMICAL SOCIETY will hold the last meeting before the Summer, Monday evening, June 9, 1919, in Newark, N. J.

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION will hold its 27th annual meeting at Johns Hopkins University, Baltimore, Md., June 25-28.

THE TECHNICAL ASSOCIATION OF THE PULP AND PAPER INDUSTRY will hold its Spring meeting at Erie, Pa., and Buffalo, N. Y., June 11-14 inclusive.

Industrial Notes

THE GELLERT ENGINEERING CO., Philadelphia, Pa., is now erecting electrical precipitators which are being installed at the plant of the American Manganese Manufacturing Co., at Dunbar, Pa., to clean the gases from the blast furnaces. They are expected to be completed by June 1.

THE UNITED STATES & CUBAN ALLIED WORKS ENGINEERING CORP., New York City, announces that Mr. J. A. King has become identified with it as works manager and will be in charge of the corporation's plant, foundry, machine shop and structural works at Havana, the Havana Iron Works, and the marine works, the Havana Dry Dock Co. It is also announced that Mr. Emile J. Bayle has joined the corporation as sales manager.

THE HUFF ELECTROSTATIC SEPARATOR CO., which has been located for the last fourteen years at 60 India Street, Boston, Mass., has recently acquired and fitted up a large plant at Arlington, Mass., a suburb of Boston, to which it has moved its offices, ore-testing and chemical laboratories and works. It maintains a well-equipped laboratory for the purpose of making either preliminary or complete tests showing the results that can be obtained commercially in the separation or concentration of minerals, abrasive materials, and reclaiming valuable content of many waste materials by the Huff Electrostatic process. Mr. H. B. Johnson, an expert in graphite refining, is general manager of the company.

THE ELECTRIC FURNACE CONSTRUCTION CO., Philadelphia, reports the successful starting up of a Greaves-Etchells electric furnace at the plant of the Davidson Tool Manufacturing Corp., Brooklyn. This furnace is used in conjunction with Mr. Davidson's special process for the manufacture of high speed steel castings. Remarkable results have been achieved in the manufacture of high speed steel cutters, drills, boring tools, etc. The company also reports the starting up of a 6-ton furnace at the Navy Department, Mare Island. In England Greaves-Etchells furnaces have been started up for the Tyne Electrical Steel Foundries, Ltd., for the manufacture of steel castings; and a special 6-ton furnace has been installed for W. W. McGregor, of Airdrie, for the manufacture of alundum.

THE MERRILL CO., San Francisco, Cal., is the successor to the Merrill Metallurgical Co., taking over the patents and commercial business of its predecessor. It expects to continue to enlarge its scope as new devices and products become available.

THE BAILEY METER CO. moved its main office and works from Boston to Cleveland, Ohio, on May 1. The Boston office, with Mr. H. D. Fisher, as manager, is retained to handle sales and engineering service work in the New England district. For the present New York and Philadelphia districts will be covered from Boston and all other districts will be covered from Cleveland.

THE OLIVER CONTINUOUS FILTER CO., San Francisco, states that conditions in Mexico are becoming more stable and that metallurgical companies are resuming operations. The American Smelters Securities Co., for example, has recently purchased for the Veta Grande mill at Parral, Chihuahua, six 12-ft. diameter by 16-ft. Oliver filters with complete vacuum equipment. The mill capacity is being increased to 600 tons daily. Sales of similar equipment have been made at the Benguet Consolidated Mines in Benguet, Philippine Islands, and to the Government cyanide plant in the Dutch East Indies.

THE ASSOCIATION OF MEMBERS OF AMERICAN NATIONAL ENGINEERING SOCIETIES IN CUBA was organized in Havana, on Feb. 21, 1919, to foster the interests of the various national engineering societies represented on the island. Membership is restricted to persons who are members of the American Society of Mechanical Engineers, the American Society of Civil Engineers, the American Institute of Electrical Engineers, the American Institute of Chemical Engineers, the American Society of Agricultural Engineers, the American Society of Refrigerating Engineers, the Mining and Metallurgical Society of America, the American Institute of Architects, the American Iron and Steel Institute, the American Chemical Society and such other societies as may from time to time be added to the list by the board of directors. It is planned to hold four regular meetings each year for the reading and discussion of papers.

Manufacturers' Catalogs

THE NORTON CO., Worcester, Mass., has issued its 1919 edition of Norton Refractories. This attractive 60-page bulletin is a complete revision of the previous catalog, and contains many additions, including an extensive range of sizes of tubes, muffles and cores, as well as newly developed shapes and a new product known as "electrically sintered magnesia." Prices are given of the various products and also illustrations. A number of tables and charts and a complete bibliography of aiundum and crystolon refractories have been compicted, which makes it useful as a reference book in connection with high temperature electric furnace products.

THE PYROELECTRIC INSTRUMENT Co., Trenton, N. J., has just issued Buli. No. 3, dated Aprii 1919, which gives in four pages illustrations and descriptive matter on the production of carbon free aiioys of high melting point. Circular No. 15 deals with continuousiy deflecting Northrup pyrovolter and pyrometer which contains circuits for checking its indications.

Stocks and Bonds

Closing Bid and Asked Quotations May 27, on N. Y. Stock Exchange

CHEMICAL COMPANIES

	Bid	Ask		Bid	Ask
Am.Ag.Ch.....	109½	109¾	Mat.Al.Wk..	31	40
do.pf.....	100¾	101	Ten. C. & C..	14¾	15
Barrett Co...	134½	135	Un. Dyewood.	61	63
do.pf.....	117	120	do. pf.....	..	96
Gen.Chem.....	190	199	Va.-Car. Ch..	73	73½
do.pf.....	102½	103¾	do. pf.....	13¾	13½
Int.Ag.Ch.....	26	27			
do. pf.....	85	85½			

Bonds

Am. Ag. Ch., 1st cv. 5s, '28.....	100	101
Am. Ag. Ch., cv. db. 5s, '24.....	106	110
Int. Ag. Ch., 1 mtg. & col. tr. 5s, '32.....	82½	83
Va.-Car. Ch., 1 mtg. 5s, '23.....	97	97½
Va.-Car. Ch., cv. db. 6s, '24.....	101½	102½

PETROLEUM COMPANIES

	Bid	Ask		Bid	Ask
Asso. Oil Co..	90¼	90½	P-A Pet & Tr.	94½	94¾
Cal. Pet.....	32	32¾	do. pf.....	160	166
do. pf.....	79½	80	Pierce Oil....	26¼	26⅜
Col. G. & E..	52¼	52⅜	Royal Dutch..	115¾	116⅛
Mex. Pet.....	182¾	183¼	Sinclair O & R	66	66⅛
do. pf.....	108	108⅜	Texas Co.....	178	179
Obio Cit. Gas.	54⅛	54⅜	Tex. Pac. Ld.		
do. pf.....			Tr.....	400	600
Ohio Fuel S...	50	51	Tidewater Oil.	248	250
Okla. P. & R..	11⅛	12			

Bonds

Columbia Gas & Electric, 1 5s, '27.....	87	89
Col. G. & El., std. 1 5s, '27.....	86⅜	87
Pan-Am. Pet. & Tr. 1 8s, '19-'27.....	150	
Pierce Oil, cv. db. 6s, '24.....	132	142
Pierce Oil, cv. 5% Notes, '20.....	109⅛	109⅜
Sin. O. & R. 1 in.7s, '20, with stk. war...	146	151
Sin. O. & R. 1 In. 7s, '20 without stk. war..	99⅞	100
Texas Co., db. 6s, '31.....	102	102½
Union Oil of Cal. 1 5s, '31.....	93⅜	94½
United Fuel Gas 1 mtg. 6s, ser.A, '36....	95½	97

IRON AND STEEL SECURITIES

	Bid	Ask		Bid	Ask
Am. St. F....	37⅜	37⅝	Pitts.Ste. pf...	90	98
Beth. Steel...	79	80	Rep. Iron &		
do. Steel B.	79¾	79⅞	Steel.....	87¾	88
do. pf., 8%.	112	112½	do. pf.....	104	104½
do. pf., 7%.	100	105	Sloss Sheff. I.		
Central Fdry.	23	23½	& S.....	63	64
do. pf.....	48¼	49½	do. pf.....	90	91½
Col. F. & I...	47¾	47⅞	Superior Steel.	49¾	50
do. pf.....	105	120	do. 1 pf....	99½	101
Cruc. Steel...	80¾	81	Trans. & W.		
do. pf.....	98	100	Steel.....	56	57½
Great No. Ore	47	47½	Un. Alloy St..	53¾	54
Gulf Sta. Steel	73½	73⅞	U.S.C.I.P.&F.	25¼	26
do. 1 pf....	93	98	do. pf.....	63	64½
Lack. Steel...	83¾	84	U. S. Steel....	107⅛	107⅜
Mid.St.& Ord.	51⅜	51¾	do. pf.....	115⅛	115⅜
Nova Scotia			Va. Cosl,I&C.	67	68
Steel	73	74			

Bonds

Beth. Steel, 1 ext. gtd. S.F. 5s, '26.....	96	96⅜
Beth. Steel, 1 In. ref. 5s, Ser. A, '42....	89½	90
Beth. Steel, P. M. & I. S. F. 5s, '36.....	86½	87
Buff. & Susq. Iron, 1 S. F. 5s, '32.....	91	96
Buff. & Susq. Iron, deb. 5s, '27.....		
Cent. Found. 1 mtg. S. F. 6s, '21.....	80	81
Col. F. & I., gn. S. F. 5s, '43.....	91	93½
Ill. Steel, db. 4½s, '40.....	85½	87
Ind. Steel, 1 mtg. gtd. 5s, '52.....	97⅜	98
Lack. Steel, 1 5s, '23.....	96⅜	97¼
Lack. Ste., 1 con. mtg. cv. 5s, Ser. A, '50	92¼	94¼
Mid. St. & Ord., clt. cv. S. F. 5s, '36....	89½	89¾
Nat. Tube, 1 mtg. gtd. 5s, '52.....	97⅜	99
Rep. I. & S., S. F. mtg. 5s, '40.....	96	98
Tenn. C. & I. R.R., gn. 5s, '51.....	91¾	95¾
U. S. Steel, S. F. 5s, '63.....	100	100⅛
Va. C., I. & C., 1 5s, '49.....	85⅜	88¼

Published SEMI-MONTHLY *on the* FIRST *and* FIFTEENTH *of each month*

CHEMICAL & METALLURGICAL ENGINEERING

A *consolidation of* ELECTROCHEMICAL & METALLURGICAL INDUSTRY *and* IRON & STEEL MAGAZINE

McGRAW-HILL COMPANY, INC.
Tenth Avenue at 36th Street
NEW YORK

JAMES H. McGRAW, President
ARTHUR J. BALDWIN, Vice President E. J. MEHREN, Vice President
J. MALCOLM MUIR, Vice President EDWARD CALDWELL, Treasurer
JAMES H. McGRAW, JR., Secretary

TELEPHONE, 2840 Greeley CABLE ADDRESS, Machinist, New York

WASHINGTON, Colorado Bldg. SALT LAKE CITY, Newhouse Bldg.
CHICAGO, Old Colony Bldg. PHILADELPHIA, Real Estate Trust Bldg.
SAN FRANCISCO, Rialto Bldg. CLEVELAND, Leader-News Bldg.
LONDON, 6 Bouverie St., E. C. 4. BUENOS AIRES, Calle Corrientes, 685.

H. C. PARMELEE, Editor
ELLWOOD HENDRICK, Consulting Editor
ERNEST E. THUM, Western Editor
WALLACE SAVAGE, Assistant Editor

Yearly Subscription price for United States, Mexico and United States dependencies, $3; all other countries, $4. Single Copy, 25c.
When change of address is ordered, the NEW and the OLD addresses must be given. Notice must be received at least 10 days before change takes place. No back copies for more than three months.

Copyright, McGraw-Hill Co., Inc., 1919. Entered as second-class matter July 13, 1918, at the Post Office at New York, N. Y., under the Act of Congress of March 3, 1879.

Circulation of this issue, 12,500 *copies*

CONTENTS *for June* 15, 1919

Volume XX, *Number* 12

EDITORIAL

Minerals Separation Wins Doubtful Victory 609
Promise of Progress in Rubber Research 610
The Duration of Prosperity 611

READERS' VIEWS AND COMMENTS

That Missing Page From the Blue-Back Speller. By *A. D. Meyer* 612
Photography in Research. By *Nathan C. Johnson* 612
Modification of the Cyanide Method for the Estimation of Nickel in Steels. By *L. F. Miller* 613
Western Chemical and Metallurgical Field 613
Fall Meeting of the American Electrochemical Society 616
Electric Power Production 617
Dedication of New Bureau of Mines Laboratories 617
April Imports and Exports 617
Alloy Steels for Helmets and Armor. By *John A. Coyle* 618
Chemists' Club Scholarships 620
Nodulizing Flotation Concentration in a Rotary Kiln With Powdered Coal. By *Robert M. Draper* 621
Notes on the Influence of Certain Variables Associated With the Anneal of Cold-Worked Alpha Brass. By *Arthur Phillips* and *George C. Gerner* 622
Effect of Sodium Chloride on Blue-Powder Formation. By *Reginald S. Dean* 628
Fusibility of Ash From Pennsylvania Coals. By *W. A. Selvig* and *A. C. Fieldner* 629
Commercial Feasibility of Electric Smelting of Iron Ores in British Columbia 630
Edgewood Arsenal Has New Commanding Officer 636
Decision on Frasch Patents on Sulphur Mining. By *Hugo Moek* and *Ashcr Blum* 638
Removal of Tin Import Restrictions 638
Kingsport, Tennessee, and Its Chemical Industries—II 639
Imports and Exports 644
Synopsis of Recent Chemical and Metallurgical Literature 645
Recent Chemical and Metallurgical Patents 647
Spur Gear Speed Reducer 648
Personal 648
Current Market Reports 649
Industrial News, Coming Meetings and Events, Industrial Notes, Manufacturers' Catalogs, New Publications and Stocks and Bonds 654

Minerals Separation Wins Doubtful Victory

ON JUNE 2 the Supreme Court handed down its decision in the Butte and Superior infringement suit involving Minerals Separation patent 835,120. This is the same patent which was under consideration in the Hyde case, in which the Supreme Court sustained the validity of the patent and defined its elements to be the use of oil in critical proportions amounting to a fraction of one per cent upon the ore, in combination with greater agitation than that theretofore used, and producing a froth different from any previously produced. But that decision did not, it now seems, define the scope of the claims. The opinion in the Butte and Superior case just handed down defines the scope of the claims as to quantity and character of the oils, and places throughout the most insistent emphasis upon the means described in the patent for carrying out the process of the patent. The process is now stated to be one employing any quantity less than one per cent, on the ore, of an oil or oily substance having preferential affinity for metal over gangue, in which air bubbles are introduced into the pulp by agitation.

As to the operations of the Butte and Superior Company the opinion says:

> The evidence shows, and counsel now admit, that prior to the decision by this court in December, 1916, the respondent used, in its ore concentration operations, various oils in quantities less than one-half of one per cent, on the ore, but that from January 9, 1917, to the time of trial, with the exception of two or three weeks, it used oils of a composition which we shall discuss later on, in quantities in excess of one per cent on the ore. In other respects its methods were substantially those of the patent in suit.

It is interesting to note the last sentence in the above quotation. The opinion adds:

> On this showing, the District Court found the patent infringed by the respondent, when it used oil in quantities greater than, as well as when it used it in quantities less than, one per cent on the ore. . . . The Circuit Court of Appeals held the patent infringed only when the respondent used oil in quantities equal to, or less than, one-half of one per cent on the ore, and it therefore reversed both of the holdings of the District Court, but allowed recovery for the period when less than one-half of one per cent of oil on the ore was used.

It will be seen that there were three periods considered as to the use of oil. The use of less than one-half of one per cent up until the time of the decision in the Hyde case; in excess of one per cent after that time, with slight exception of the periods during which the use of oil was over one-half per cent but less than one per cent.

The Circuit Court of Appeals decided that oil in excess of one-half of one per cent did not infringe; it

> derived its authority to limit the claims to one-half of one per cent on the ore from the construction which it

placed upon the following clause of the opinion of this court in the former case, viz.:

"The patent must be confined to the results obtained by the use of oil within the proportions often described in the testimony and in the claims of the patent as 'critical proportions,' 'amounting to a fraction of one per cent on the ore.'"

The reasoning which carried two members of the court to their conclusion was that, as shown by the evidence of the patentees and the argument of their counsel, the amount of oil which is "critical" in the sense of marking the point of transition from the processes of the prior art to the process and discovery of the patent is one-half of one per cent of oil on the ore, and that therefore this court, by using the expression quoted, intended to limit the claims, not to a "fraction of one per cent" but to a "fraction of one-half of one per cent on the ore."

But the Supreme Court reversed the Circuit Court of Appeals, saying:

> The two expressions "critical proportions" and "amounting to a fraction of one per cent on the ore" being used, the former derived from the evidence and the latter from the claims of the patent, obviously, to the extent that they differ—if they differ at all—the language of the claims must rule in determining the rights of the patentees.

Judge BOURQUIN in the District Court had found oil used by the defendant in excess of one per cent an infringement upon the theory that kerosene and fuel oil were of no benefit, when used in a mixture having a quantity of pine oil sufficient in itself to produce the results of the process, and decided that therefore the kerosene and fuel oil should not be figured into the calculation to determine the percentage of oil upon the ore. The opinion asks:

> Does the use of a more efficient, in combination with a less efficient, oil of the patent constitute infringement, where the former is used in an amount within the limits of the claims but the combined amount is in excess of such limit, and when the amount of the more efficient oil used would probably produce better results from the process than are produced with the combination of oils?

Without quoting fully all of that part of the opinion conveying the answer to the above we would state that it is based upon the scope of the claims as well as upon a consideration of the state of the prior art at the time the patent was made, the court saying among other things:

> We held in the former case that the patentees came late into the field of ore concentration investigation and that their discovery rests upon a prior art so fully developed that it was "clear from the record that approach was being made slowly but more and more nearly to the result which was reached by the patentees of the process in suit in March, 1905," and that their final step was not a long one.
>
> Such a patent, in such a field of investigation, must be construed strictly, but candidly and fairly, to give to the patentees the full benefit, but not more, of the disclosure of their discovery which is to become part of the public stock of knowledge upon the expiration of the patent period, and which was the consideration for the grant to them of a patent monopoly.
>
> From this consideration of the terms of the patent as written, it is apparent that it makes no differentiation whatever, either in the claims or in the specification, among the oils having a preferential affinity for metalliferous matter, and that its disclosure, to which the petitioners must be limited, is that when a fraction of one per cent on the ore of any such oil is used in the manner prescribed there will be produced a metal-bearing froth, the result of the process. No notice is given to the public, and it is nowhere "particularly pointed out" in the claims, that some oils or combination of oils, having a preferential affinity for metalliferous matter, are more useful than others in the process, or that some may be used successfully and some not, or that some are "frothing oils," a designation not appearing in the patent, and that some are not. The patentees discovered the described process for producing the result or effect, the metal-bearing froth, but they did not invent that result or froth—their patent is on the process, it is not and cannot be on the result—and the scope of their right is limited to the means they have devised and described as constituting the process.
>
> That the only disclosure as to the kind and amount of oil which the patentees made to the public as necessary to the practicing of their process is that it must be an oil and oily substance, or oily liquid having a "preferential affinity for metalliferous matter," and that it shall be limited in amount "to a fraction of one per cent on the ore."

From the above quotations it is to be seen that the Supreme Court reverses the Circuit Court of Appeals as to its finding with respect to the use of oil between one-half of one per cent and one per cent, but sustains that court as to the non-infringing nature of the defendant's use of oil in excess of one per cent. It reverses the District Court as to Judge BOURQUIN'S opinion regarding the distinction between "frothing oils" and "non-frothing oils" in the most emphatic manner saying:

> To give such a construction to the patent would subordinate the clear description contained in it of what are oils of the process, to an implied and vague description and classification which would leave the whole subject again at large, to become a field for further experimentation, without definition in the patent of what oils or froths would satisfy it.

Referring to the evidence which had led it to the above decision, the Supreme Court says:

> Much of this evidence is especially impressive because the papers from which it is derived were written and the witnesses testified before the question as to petroleum, now made in this case, was raised or discussed.

This apparently imputes a change of front upon the part of Minerals Separation made to meet the exigencies of the case. Such a change of front is also found in Minerals Separation's reducing the violence of agitation as described in the Hyde case in an effort to conform the same patent to the conditions of the pneumatic cell.

A careful reading of this opinion with its numerous phrases emphasizing the necessity of confining the patentees to the "means" of the process as set forth in the patent claims would seem to make it of even greater embarrassment than the Hyde opinion appears to have been when applied to the pneumatic cell. All of the citations to cases made in this opinion as applied to the quantity and character of oil covered by the claims, it seems to us, would apply with equal force to the scope of the claims as to the manner of introducing air bubbles into the mass, which is the question involved in considering the application of patent 835,120 to the pneumatic cell.

The decision is against the Butte and Superior Company in that it brings that company to an accounting for its use of oil in quantity less than one per cent in a process of which the decision says, "In other respects its methods were substantially that of the patent in suit."

Promise of Progress In Rubber Research

THE organization of a Rubber Chemistry Division of the American Chemical Society is to be hailed with favor and all good wishes. The industry has thrived in this country, and it has produced vast wealth, but this has been the result of circumstance rather than because of wisdom and vision within the manufacturing organizations. Some manufacturers have always been progressive, but not all of them, by any means. Most of them employed chemists because they had to, and if

these men could get time off to visit meetings of scientific and technical associations they were usually under instructions to sit still and say nothing, but to bring back whatever they could learn of their competitors' methods and practices.

That is supposed in some quarters to be the very peak of diplomacy and astuteness. When a man of high authority in a manufacturing corporation conceives a thought of that nature his chest swells, and all his little admirers call him a wonder and declare that nobody can beat him! But in the brotherhood of American chemical industries rubber has been scientifically backward, and this is not the fault of the chemists. There has been a lack of men of scientific training on the boards of directors, and. as we have said before and expect to say again, it requires more than business acumen to see the light of science.

It is high time for the rubber industry to take a hitch in its belt and dig into the philosophy of rubber chemistry. The Division provides a start. We shall have now to meet the question whether the authorities will see clearly enough beyond the walls of their works to understand that the way to get ahead is to work together, to permit and encourage chemists to work at research, and to make known their findings. We doubt if there is a single establishment far enough ahead of the game to meet real, intensive research if the manufacturers of some other country should awaken to its value.

In this connection we are always fond of recalling a statement of Dr. JAMES DOUGLAS in one of his "Non-Technical Essays on Technical Subjects," to the effect that those who close the door against the release of information simultaneously raise an equally effective barrier against any knowledge filtering in. The rubber industry of today can learn a profitable lesson from a comparison of present conditions in the iron and steel industry with those of the "good old days" before the spread of technical knowledge.

The Duration Of Prosperity

IF THE steel industry is really the barometer of general trade, it is unfortunate that the barometer cannot be read more closely. For fully a month there have been improved conditions as to steel demand, yet it is uncertain whether the improvement represents merely a delayed spring buying movement or the beginning of a general movement of major proportions.

As to trade in general, it is now rather widely admitted that there is no occasion for men to wait for much lower prices before making purchases or investments. Price deflation has not occurred to any extent and is practically certain not to occur in the present order of things. What occurred after the Civil War is likely, in a general way, to be repeated. There was no price readjustment, to speak of, after the Civil War, but eight years later there came a great panic and then a severe industrial depression of five years' duration.

Many men are now of the opinion that business after the Great War will follow somewhat the same course. This may be a reasonable and correct conclusion, but some men are disposed to apply this conclusion to their conduct in a way that may prove very dangerous. They assume, first, that there will be a gradual deflation in prices and, second, that they will be able to discern the impending depression in time to "get out from under." Now the fact is that the course of iron prices after the Civil War shows conclusively that such a doctrine is very dangerous.

In the first place, there was no clearly marked deflation of prices during the eight years of activity that followed the Civil War, and in the second place men did not foresee the panic and depression that followed and consequently they were quite unable to save themselves.

The prices to be studied, as most indicative of the general trend in the iron industry, are the prices of No. 1 anthracite foundry pig iron at Philadelphia. Then, as now, there was a "pre-war" average of prices, but in view of the exceptionally high prices of 1853 and 1854 a five-year average, 1856 to 1860 inclusive, seems to be the fair one to take. This average was $24.37. There was no Government price control in the Civil War, and the maximum price during the war was $73.75, in August, 1864. In the spring of 1865, at the close of the war, pig iron was $50, or a trifle more than double its pre-war average.

If any one expected materially lower prices to follow the war's ending he was disappointed. There was a slight decline, but in November, 1865, pig iron was $51. Then there was a series of declines and advances, quite suggestive that pig iron was gradually sagging, the low points being successively lower. The lowest decline was to $30, in January, 1871. Then, however, any theory of a gradual and progressive deflation was completely knocked out by facts, for an advance occurred which raised pig iron to $54 in September, 1872, a price higher than obtained when the war closed more than seven years before. One year later, September 19, 1873, occurred the great Jay Cooke panic.

From this sketch of the course of the iron market, presumably as much the barometer of trade then as now, it is readily seen there was no opportunity for one to foresee and prepare for the industrial depression. More than seven years after the war ended and only one year before the panic pig iron was at a higher price than at the close of the war or at any intermediate date.

The only theory that would have saved one from loss would have been to "copper" the market, to conclude that when pig iron had reached such a level as that of September, 1872, it was time to run quickly to cover.

Equally unprofitable would it have been for any one, in 1865 or 1866, to "wait for lower prices," for one might have waited from the war's ending through seven and a half years of great activity, only to find the price higher than ever. The wait for the lowest price of all would have lasted until November, 1878, when pig iron was $16.50. That wait would have lasted more than 13 years, and one whole opportunity would have been passed. It would have paid well to take hold afresh in November, 1878, for the $16.50 pig iron of that month was followed by $41 pig iron fifteen months later.

The experience of what occurred in iron after the Civil War may or may not be suggestive of what is to occur in the next few years, but if the history of those times is to be taken as any guide at all, it should be taken precisely. One should have an exact, not a hazy and more or less inaccurate, conception of what occurred.

Readers' Views and Comments

That Missing Page From the Blue-Back Speller

To the Editor of Chemical & Metallurgical Engineering

SIR:—Referring to the editorial "That Missing Page From the Blue-Back Speller" in your issue of Dec. 15 last, and to the various comments and discussions on the same, I note that the writers in each case have a particular application in view and do not seem to apply their reasons to general practice. Yet they wish the readers to believe their statements to embody all methods of steel manufacture.

Practice has proved in some plants that the proper pouring temperature of steel is just a few degrees (anywhere from 50 to 100) above the upper freezing point. This means that with a normal size heat of about 50 tons there remains a skull in the ladle after finishing pouring.

But there are certain other practices where a skull is unnecessary, and in fact a pouring which results with skull is frowned upon. The manufacture, in some plants, of bottom-poured ingots for boiler plate is a good example of this latter practice. This steel is the effervescing kind (so named by Henry D. Hibbard), which should always be cast at sufficiently high temperature to permit the escape of considerable amount of gases from the metal during teeming and for several minutes after the molds have been filled. For this practice, then, it is necessary that the metal be so hot as not to permit any resultant skull in the ladle.

With this practice it has been found fitting and proper that the cold additions be made in the ladle instead of in the furnace. When these additions are made in a very fine stream to the metal flowing from the spout the difficulty is eliminated of the steel freezing about the cold solid particles of ferromanganese and the necessity of remelting the combination before the manganese becomes of service. Furthermore, when the ferromanganese is added to the stream of metal from the spout, and when the metal is hot enough to leave no skull in the ladle, there is never any fear of the manganese being unevenly diffused throughout the heat.

By adding ferromanganese to the ladle it is done at a time when the oxidizing influence of the slag and the reducing action of the flame have been removed. The metal is in a passive or neutral state. The stage is, therefore, set for the full and complete reducing action of the manganese. Its whole influence is exerted on the oxides and sulphides in the metal and a clearer, less oxidized metal results. What reduction takes place then is not undone by the slag, such as invariably occurs to a limited extent when additions are made in a basic furnace.

It is felt that the greater loss of manganese, stated by a recent writer, occurring when the ferromanganese is added to the furnace is due not primarily to the activity of the manganese in removing the oxygen, but this loss is due to the oxidizing effect of the slag on the element.

As was stated at the beginning of this article, each discussion on the above topic has been from one specific point of view, but each writer felt he had covered the ground as general practice. I myself have laid before you another specific practice, but I do not wish to generalize it.

My story is not to criticise the practices as brought forward by the several writers, but merely to make plain that the conditions of manufacture are the underlying principles with regard to the addition of cold solid additions in the ladle and that the "Missing Page" must be supplied according to the requirements of the individual practice.

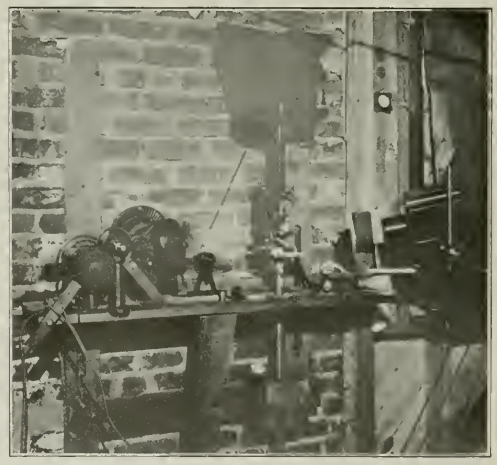
A. L. MEYER.

Coatesville, Pa.

Photography in Research

To the Editor of Chemical & Metallurgical Engineering

SIR:—I have noted with interest the article in your recent issue descriptive of an application of microscope and motion picture camera to the structure of steel under stress. It may be of interest to your readers to know that a similar combination of apparatus has been used by the writer for some five years past in the study of the setting processes of concrete as affected by temperature and other variables; the manner in which cement attaches itself to sand and to stone; the processes incident to attack by fresh and sea water on concrete; disruption by frost; stressing and disruption of concrete



MOTOR-DRIVEN APPARATUS FOR TAKING PHOTOS AT REGULAR INTERVALS

under strain; shrinkage and crazing through evaporations; the effect of temperature; humidity, etc.; on rusting of steel (rust is disclosed as a phenomenon of rare beauty); the oxidizing and deterioration of paints and protective coating; and various other matters of professional interest to me. As a result of these studies, new processes which give promise of wide usefulness are nearing commercial success. A lecture with such films as relating to concrete has been delivered at various places this year and seems materially to have assisted the understanding of auditors as regards these usually obscure and unknown processes.

For the taking of accurate studies, in all of which time enters as a most important factor, the hand-actuated camera shown in your illustration was early discarded. In its place, the motor-driven apparatus shown in the

illustration herewith was constructed from stock gears and a $10 camera of early vintage. By its means, pictures may be taken at any desired intervals from $\frac{1}{10}$ second to 3 hours between exposures, unvaryingly, day and night over protracted periods. Furthermore, as this has been a diversion as well as a serious study, the use of automatic means has permitted attendance on other duties without interruption.

I would further say that the use of oblique illumination of opaque objects and of dark ground illuminator for transparent or semi-transparent subjects extends the range of research far beyond those included within the possibilities of vertical illuminators.

The general scheme is an admirable tool. Let us hope for its early and general extension of use.

New York City. NATHAN C. JOHNSON.

Modification of the Cyanide Method for the Estimation of Nickel in Steels

To the Editor of Chemical & Metallurgical Engineering

SIR:—The method, as outlined below, is the common cyanide method, using ammonium citrate to hold the iron in ammoniacal solution—with several differences. The differences are the method of introduction of the silver nitrate into the solution to be titrated and the elimination of hydrochloric acid in dissolving the steel.

It is a fact not generally known among iron and steel chemists that silver nitrate is soluble in concentrated potassium iodide solution, due to the formation of a double salt. (See Prescott and Johnson, Qualitative Analysis.) This double salt breaks down to silver iodide and potassium nitrate on dilution. This modification takes advantage of these facts by the use of an indicator solution containing silver nitrate and potassium iodide, the only precautions being necessarily the use of this indicator in definite quantity in each determination and the determination of a blank, to be subtracted from each titration.

The method as at present in use in this plant is:

Weigh a 1-g. sample into a 250-cc. beaker, dissolve in 30 cc. nitric acid (1.20 sp.gr.) and evaporate to 8 or 10 cc. Remove from the hot plate and add 50 cc. sulphuric and citric acid solution. Cool, make faintly but distinctly alkaline to litmus paper with ammonia and dilute to 150 to 175 cc. Cool to room temperature, and add exactly 2 cc. special indicator, from a pipette or a burette, and titrate with standard potassium cyanide solution until the solution just clears.

SPECIAL INDICATOR

0.2925 g. Silver nitrate
30.0 g. Potassium iodide
Distilled water to make the volume 100 cc

SULPHURIC AND CITRIC ACID SOLUTION

200 g. Citric acid
600 cc. Distilled water
400 cc. Sulphuric acid (1 to 3)

STANDARD POTASSIUM CYANIDE SOLUTION

4.5 g. Potassium cyanide (or equivalent in sodium cyanide)
1000.0 cc. Distilled water
5.0 g. Potassium hydroxide may be added, but is not necessary.

Standardize by putting 1 g. of a standard steel through the above manipulations. A blank, representing the amount of standard solution necessary to clear 2 cc. of the special indicator, must be deducted from all titrations. This blank is best determined by running a nickel-free steel through the method, but diluting 2 cc. of the special indicator to 150 cc. with water, and titrating, will be sufficiently accurate for routine work.

Anderson Forge and Machine Co.
Detroit, Mich. L. F. MILLER.

Western Chemical and Metallurgical Field

Pig Iron, Ferros and Sponge Iron at Heroult

IN VIEW of the fact that the Noble Electric Steel Co. has been a pioneering experimenter in electric pig iron on the Pacific Coast, its friends will be glad to know that its most recent investigations on low-temperature reductions have been very encouraging, and entirely successful in a small-scale unit.

Electric smelting was commenced by this company in 1907 under the direction of H. H. Noble, when the late Dr. Paul L. T. Heroult constructed a 2000-hp. rectangular furnace with arched roof, having three electrodes alternating with four vertical charge chutes. Escaping gases were led upward through these chutes to preheat and reduce the ore, but in operation the heated ore hung in the chutes, and a very hot top melted the roof. Some iron was made in this early furnace, but a single-phase furnace of 160 kw. was built in 1908 under direction of Dorsey A. Lyon, and this was followed the next year by a tall shaft furnace (quite similar to the independently developed Swedish type), whose operation continued intermittently two years. With the latter it was found extremely difficult to control the carbon in the resulting pig iron (soft, high-silicon foundry iron was desired by the available market), since excess carbon could not be burned off, and deficiencies of carbon and segregation of constituents often occurred during settlement of the charge. Long, narrow, closed-top furnaces of 2000 and 3000 kw. capacity similar to Dr. Heroult's were therefore built in 1912, and continuously operated without preheating the ore in the charging chutes. John Crawford described the results from these furnaces in METALLURGICAL & CHEMICAL ENGINEERING, July, 1913, Vol. XI, p. 383. Iron containing 2.9 per cent Si, 0.1 per cent combined carbon and 3.4 per cent graphitic carbon was made with a minimum power consumption of 2200 kw.-hr. per ton (0.40 hp.-yr. at 85 per cent load factor).

Other circumstances than undeveloped technology militated against the success of the Noble Steel Co. Its plant is situated in the northern part of California in mountainous country removed by long rail haul from the source of the company's miscellaneous supplies and its market. Ore and flux are near by, but the timber was rapidly exhausted. As a last straw, the men most interested in the steel company lost control of the Northern California Power Co. in 1914 and their rates for energy immediately doubled, forcing a closure of the plant as far as the commercial production of pig iron was concerned. A very good quality of pig iron was made in one of their open pit furnaces in a campaign during the months of January and February of the present year. This furnace had an open top, and had been used to produce various ferro-alloys. Over 95 per cent of the iron in the ore charged was recovered as metal with a power input of 2400 kw.-hr. per short ton of pig iron.

As an offset to the many disappointments as iron producers, the following brief record of successful alloy practice should be made:

In 1907, Petinot, using the original Heroult furnace, made ferrosilicon, and plans were made for the production of ferrochromium. Owing to the lack of a ready market for the alloys, this work was set aside, and all effort concentrated on the iron problem during the following seven years.

In the fall of 1914, Crawford made ferromanganese in the furnaces described by him in METALLURGICAL & CHEMICAL ENGINEERING, Vol. XI, p. 383, but he was unable to co-ordinate the electrical and metallurgical conditions of the burden in a closed-top furnace, and still produce a standard alloy with the low-grade ore supplied him.

In 1915, Scott, followed by Gosrow, using the smaller Crawford furnace with the top removed, established a good furnace practice on ferromanganese with ore of standard specification. They were forced to discontinue operations, however, when the grade of ore fell off.

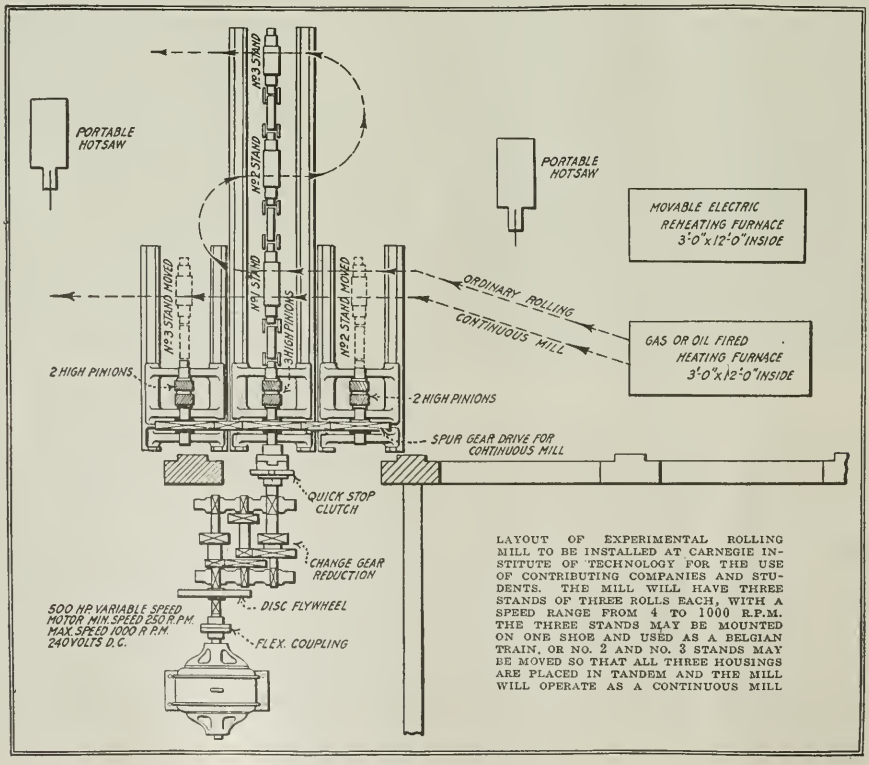
From April, 1916, until March, 1919, the plant ran continuously on ferro-alloys, with operations varying in volume from one to four furnaces, as raw materials could be obtained. During this period, ferromanganese was the main product, and ferrosilicon, ferrochromium, silicomanganese and pig iron were produced in small amounts when the demand was strong. During these latter operations, the problem of low-temperature reduction of iron ores was approached—not an entirely new venture to the Noble company, since about seven years previously, in 1911, it installed a series of small portable electric furnaces for making sponge iron, and a large tilting type (2000-kw.) furnace for melting. A mechanical device, similar to the open-hearth charging machine, periodically emptied the contents of a small furnace into the melter. Mechanical difficulties and lack of metallurgical control soon caused the abandonment of this experiment, however.

Recently these attempts were revived in view of the large increase in power cost. It is essential to reduce its consumption if electrical smelting is to succeed, and the most promising method seemed to be to separate the reduction stage from the melting stage.

According to Dr. Stansfield's recent report on the commercial feasibility of the electric smelting of iron ores in British Columbia, reduction can be done at 700 to 800 deg. C., and absorbs about twice as much heat as the actual melting, which involves a high temperature—1400 to 1600 deg. C. In a combination process, electricity might be used for the development of the high melting temperatures only, for which it is most efficient. In this manner, simple melting can be done with 600 to 700 kw.-hr. per ton, while reduction followed by melting requires nearly four times as much power.

Dr. Trood and Mr. W. A. Darrah carried out a series of experiments following this idea at Heroult last year, using the Noble Steel Co.'s pure magnetite. The work was done in a small furnace, electrically heated, making a few pounds of reduced iron per hour. Reduction of magnetite by powdered charcoal commences in the neighborhood of 700 deg. C., but commercially it would appear to be advisable to speed up the reaction by operating nearer 800 deg. C., at which it requires about three hours effectually to reduce ore particles the size of coarse sand. The resulting sponge can then be melted electrically to either pig iron or steel, or, after briquetting, melted in a gas-fired open-hearth furnace.

From these rather small-scale experiments, Mr. Darrah



estimates the cost of sponge iron at $19 per ton. His items for crushing, handling and labor are possibly somewhat optimistic, while charcoal costs, though apparently very high, are still considerably less than the present market in those regions.

His items are as follows:

Item	Cost	Quantity Required	Total Cost per Ton of Iron
Power for drying and reduction	4c. per kw.-hr.	1,200 kw.-hr.	$6 00
Charcoal	$25 per ton	570 lb.	7 10
Ore	$3 per ton	2,760 lb.	4 15
Crushing materials	50c per ton		.69
Handling materials	50c per ton		.69
Labor and supervision			.50
Interest and depreciation on $20,000 investment			10
Total			$19 23

In commenting on these figures, Dr. Stansfield notes that the charges appear very small, but are perhaps not underestimated, owing to the continuous nature of the mechanical operations and the small amount of labor required.

Accepting Mr. Darrah's figures, Dr. Stansfield compares the cost of a ton of foundry iron by the direct process to that of white iron in a Swedish furnace (British Columbian conditions) as follows:

	FOUNDRY PIG FROM SPONGE IRON			WHITE IRON IN ELECTRO-METALS FURNACE		
	Plant Capacity 36,500 Tons Yr.	Rate	Amount	Plant Capacity 27,000 Tons Yr.	Rate	Amount
Ore	2.2 tons	$4 00	$8 80	2 tons	$4 00	$8 00
Crushing	2.2 tons	.50	1 10			
Handling	2.2 tons	.50	1 10			
Producer gas for reduction	Coal at $4		2 50			
Charcoal for reduction	½ ton	6.00	2.00			
Labor and supervision			.85			
Interest and depreciation			.25			
Total for sponge iron by gas			$16 60			
Electric power	750 kw.-hr.	0.5c.	3 75	2500 kw.-hr.	0.5c	12 50
Charcoal	0 1 ton	6 00	60	0 4 ton	8 00	3.20
Electrodes	7 lb.	8.5c.	60	15 lb.	.08	1.20
Fluxes and supplies			55			
Repairs and maintenance						1.00
Labor and supervision			3 00			6.50
Interest and depreciation			1 50		16%	2.60
Royalty						0 50
Total cost			$26 60			$35 50

Steel Research Laboratory

It was announced in April that Prof. W. Trinks of the Carnegie Institute of Technology had secured the interested co-operation of a number of steel companies and equipment manufacturers in the Pittsburgh district in organizing a Bureau of Rolling-Mill Research. This bureau will be under the direction of Mr. W. B. Skinkle and supported by funds advanced by the co-operating firms. The accompanying sketch of the proposed installation is self-explanatory, and immediately suggests the wide range of data which can be secured.

Adequate indicating instruments will be installed, so that not only the metallurgical results but the main stresses in the stands, rolls and pinions may be studied during variation in the speed of rolling, the degree of reduction, the diameter of rolls, the shape of the pass, or the analysis and temperature of the steel.

This bureau, in addition to its program of studies such as noted above, will distribute the derived information to the contributing firms for commercial exploitation, and will provide facilities for special researches by their engineering staffs, as well as constituting a laboratory of instruction for regular and special students at Carnegie Tech.

Company Reports

Calumet & Arizona Mining Co.—The smelter at Douglas operated continuously, but on a reduced ore tonnage, amounting only to 68 per cent of capacity. Ore receipts are continually decreasing in oxidized mineral, and in case proper and economical crushing arrangement can be worked out, all the material will be roasted and sent to reverberatories, practically disusing the blast-furnace department. During 1918 376 blast-furnace-days smelted 313,695 tons of dry charge, compared to 602,272 dry tons treated in 1065 reverberatory-furnace-days. Header flues for the latter furnaces were rebuilt of refractory brick to larger dimension, directly increasing the smelting capacity 40 per cent. Some blast-furnace jackets in continuous service since June, 1913, were replaced owing to corrosion of the water surfaces, the inner face exposed to the heat showing very little wear.

New Cornelia Copper Co.—This company has completed its first full calendar year as a producer of copper. During this year all bonds were converted into stock, the greater part of the indebtedness liquidated, and a first dividend of 25c. per share paid. Production was as follows:

Electrolytic cathodes	21,764,642
Cement copper	19,990,666
Copper in ore shipped	4,694,831
Total	46,950,139

Operating and general expenses, freight, refining, selling, taxes, interest and depreciation amount to $7,490,000, a total of nearly 16c. per pound. Apparently about 13,000,000 lb. of this copper was on hand at the end of the year, or more than a quarter's output, so operations were curtailed to 60 per cent of capacity on Feb. 1, 1919. In order to increase the plant to a monthly production in excess of the 3,000,000 originally designed, a fourth motor-generator set for electrolytic power is being installed a fifth unit of 3 Symons disc crushers added to the fine crushing plant, the SO_2 reduction capacity doubled by the addition of two large towers. Nearly 1 lb. of copper per ton was saved by giving the leached ore five instead of four wash-waters. It is anticipated that the mine will be able to produce 5000 tons daily of sulphide ore (1.6 per cent copper) within three years. Consequently $160,000 was appropriated for a 500-ton test mill to determine largely the proper method of grinding the ore and the correct flotation practice. This mill is now nearing completion. "The operation of the New Cornelia Co-operative Mercantile Co. was very successful. A discount of 15 per cent on purchases for the year was paid to 773 employees."

American Smelting and Refining Co.—This company was able to accumulate earnings applicable to dividends of $7,700,000 despite the pessimistic statement of President Daniel Guggenheim in the preceding report that "By these two governmental actions, first, by reducing the value of our product, and, second, by constantly increasing our cost, this great corporation . . . is having its ability to pay a fair return to its stockholders seriously jeopardized." The report for 1918 further recites that during the last three years nearly $20,000,000 has been expended for new property and construction in addition to renewal of absolescent construction, the cost of metals carried has increased over $17,000,000, and the demand on excess cash resources further increased to a total of over $42,000,000 by Liberty Bond holdings, all of which have been met without necessity

of borrowing. The board of directors may thus be pardoned their justifiable pride in their conservative management. "A comparison of the condition of the company in 1902 and of the two companies [A. S. & R. Co. and American Smelters Securities Co.] will be instructive, the figures given in the following table being approximate only:

	1902	1918	Increase, Per Cent
Quick assets	$18,000,000	$50,000,000	175
Profit and loss account	2,900,000	27,000,000	816
Annual turnover	82,000,000	390,000,000	372

Further quoting from the report, "The most discouraging condition during the war years has been the great increase in our costs of smelting and refining, while the company was without power to correspondingly increase the charges to the mines for doing this work. But these costs are already considerably decreased, and although pre-war costs may never be realized again, the board does expect that pre-war profits per ton of ore smelted will be obtained as soon as normal business is resumed."

Inspiration Consol dated Copper Co.—Successful operations continued despite a shortage of labor and a corresponding decrease in its efficiency; comparative mill statistics are as follows:

	1916	1917	1918
Tons milled	5,316,350	3,891,075	5,110,101
Average rate per section	897.8	936.7	956
Mill feed, per cent copper	1.548	1.388	1.361
Mill tailings	0.397	0.355	0.380
Flotation concentrates, per cent copper	37.50	35.57	35.26
Sulphide recovery, per cent	90.95	89.73	88.51
Gallons water per ton ore	226	348	310
Ball consumption, lb.	1.76	1.82	1.82
Flotation oils per ton, lb.	1.287	1.32	1.35

Nipissing Mines Co., Ltd.—High-grade ores have been treated for seven years by an amalgamation process using large quantities of mercury. The war-time increase in price from about $35 to $130 made this process so expensive that it was decided to rely upon cyaniding alone, after giving the ore a preliminary treatment with bleaching powder in the tube mill. The necessary apparatus for this change was installed in the low-grade mill, and the high-grade mill shut down about the middle of the year, but will probably be revived as soon as the price of supplies justifies the step. In the low-grade mill at present the ore is crushed by stamps in cyanide solution and sent to the roughing tables without classification. The tailing from the tables is classified, the sand being recrushed in tube mills, and the undersize sent to the fine sand tables. The tube mill discharge is returned to the classifier, while the tailing from the fine sand tables is cyanided. By this method 48 per cent of the silver is recovered in the form of a concentrate, 40 per cent as precipitate from the cyanide plant, and 12 per cent is lost. The concentrate is retreated in the high-grade mill with high-grade ore, and the precipitate from both treatments is sent to the refinery, where it is converted into bullion. This process can give a better extraction at a lower cost than can be obtained by cyanide alone on the present quality of ore, due consideration being given for the value of the cobalt in the concentrate.

United States Smelting, Refining & Mining Co.—Operations in Mexico appeared to have run on a normal basis, the two mills at Real del Monte and Pachuca having treated 690,000 tons of ore. This tonnage will be increased to about 80,000 tons per month on completion of additions now under construction. In Utah, on account of the abnormally large ore supply available at the Midvale plant, it was found advisable to enlarge the installation by one blast-furnace. For a short time all seven of these furnaces were in operation, but for the remainder of the year one or two of them were down. The zinc operations were not so successful, since a failure in the gas supply caused the closing down of the Checotah smelter early in the summer. The Mammoth smelter at Kennett, Cal., operated throughout the year at capacity, in spite of difficult conditions in labor and material supply. Experiments have continued on the new electrolytic zinc process, but production cannot be expected until more favorable market conditions occur. Construction of the surface plant at Sunnyside was completed, and the mill gave promise of fulfilling all expectations. This plant was seriously damaged by fire within the past few weeks, however.

Consolidated Arizona Smelting Co.—A program of reconstruction started four years ago was practically brought to completion during 1918 with results in operation fully justifying preliminary estimates. For instance, the new roadster plant and its accessories, costing a total of about $300,000, has saved approximately $100,000 in improved metallic extraction during the first year, in addition to an operating economy of about $150,000. There is apparently little justification in maintaining antiquated departments when a modern design nearly pays for itself in 12 months. Improvements in reverberatory smelting have increased the capacity to a point where blast-furnace smelting had been discontinued, and notwithstanding large increases in cost of labor and supplies (especially fuel oil) and a corresponding increase in mining and milling costs, copper was produced in 1918 for 14.683c. per lb. as against 14.98c. in 1917.

Phelps-Dodge Corporation—The following is a tabulation of the milling data contained in the last annual report:

	Moctezuma	Burro Mountain	Morenci
Dry ore milled, tons	762,029	585,083	449,990
Copper content	3.392%	1.928%	1.910%
Tailings	0.627%	0.630%	0.519%
Extraction	85.6%	70.2%	76.2%
Gallons fresh water per ton	666	737	.....
Kw.-hr. per ton	12.54	10.16	.....

At Burro Mountain the proportion of sulphide copper in the ore decreased to 1.65 per cent, which caused a slight drop in sulphide in tailings to 0.44 per cent. Extensive experimental work has developed the fact that fine grinding in closed circuit, more flotation units and additional tables below flotation will increase this extraction, and plans are being drawn up for a corresponding revision in the flow sheet.

Stripping operations on Sacramento Hill (Bisbee District) have been about 30 per cent completed, and at the present rate a daily production of 4000 tons of ore can be maintained within 18 months. The new concentrator for this service was designed under direction of H. Kenyon Burch, but its construction has been postponed until market conditions are more favorable.

Fall Meeting of the American Electrochemical Society

The next meeting of the American Electrochemical Society will be held in Chicago, Sept. 23 to 25 inclusive, during the week of the National Exposition of Chemical Industries. This Middle West meeting in conjunction with the Exposition affords a combination of circumstances which will undoubtedly bring a large attendance. Work on the program is actively under way by the officers of the Society and a symposium on catalysis is being arranged as a special feature.

Electric Power Production

THE following table is based on a report issued by the Geological Survey for the month of February, 1919. Returns were received from 3150 electric power plants engaged in public service, including central stations, electric railways and certain other plants the output of which contributes to the public supply. As these returns represent 85 per cent of the total capacity, estimates of output were made from available information for those plants which did not make returns or which were unable to furnish the data requested.

ELECTRIC POWER PRODUCTION MONTH OF FEBRUARY, 1919

State	Capacity, Kw.	Thousands of Kw.-Hr. Produced By Water-Power	By Fuels
Alabama	165,688	39,372	12,939
Arizona	91,363	3,967	16,395
Arkansas	32,358	77	6,275
California	852,956	190,462	38,295
Colorado	131,027	13,161	17,271
Connecticut	252,130	12,419	38,643
Delaware	20,617	0	5,549
District of Columbia	66,450	0	18,094
Florida	59,304	678	11,257
Georgia	214,250	35,497	7,236
Idaho	115,439	42,050	259
Illinois	804,329	13,701	241,930
Indiana	319,348	3,761	56,151
Iowa	291,635	44,214	23,110
Kansas	156,114	1,267	29,203
Kentucky	104,889	4	18,900
Louisiaoa	52,639	0	14,034
Maine	92,927	16,611	132
Maryland	128,879	278	18,448
Massachusetts	748,698	19,147	102,844
Michigan	476,913	49,980	97,187
Minnesota	292,335	24,525	28,708
Mississippi	34,315	0	5,789
Missouri	291,170	4,297	37,212
Montana	237,476	69,220	1,552
Nebraska	90,462	810	16,022
Nevada	10,630	2,913	137
New Hampshire	47,938	4,660	2,188
New Jersey	343,214	165	79,153
New Mexico	12,830	59	1,272
New York	1,836,029	204,590	288,986
North Carolina	172,217	43,234	2,820
North Dakota	20,939	0	2,308
Ohio	829,161	2,309	181,766
Oklahoma	68,013	223	12,092
Oregon	112,008	27,034	3,259
Peonsylvania	1,132,174	55,066	243,098
Rbode Island	159,175	383	28,767
South Carolina	195,192	64,745	3,235
South Dakota	34,449	4,624	3,751
Tennessee	170,272	43,780	8,368
Texas	202,101	165	43,151
Utah	76,832	48,906	0
Vermont	86,071	13,777	209
Virginia	186,150	17,693	17,685
Washington	275,802	71,160	5,667
West Virgioia	187,556	1,453	51,584
Wisconsin	351,215	28,284	32,709
Wyoning	21,031	251	3,542
Total	12,665,309	1,220,972	1,879,182
Combined total			3,100,124

The power produced by fuels (1,879,182,000 kw.-hr.) resulted from the combustion of 3,007,815 short tons of coal, 662,770 bbl. of petroleum and derivatives and 1,693,401,000 cu.ft. of natural gas.

Dedication of New Bureau of Mines Laboratories

The Bureau of Mines announces that during the week of Sept. 29 the new million dollar laboratories and workshops in Pittsburgh, Pa., will be formally dedicated. High officials of the Government, together with the Governors of the principal mining States and the leaders in the mining industries and miners' organizations, will be present to take part in the dedicatory ceremonies. A feature of the dedication will be a great national Safety-First meet, teams of miners from all over the country competing for cups and medals. There will be contests in rescue work and in first aid to the injured, and as there is immense rivalry between the teams of the different mining companies, it is expected that these contests will take at least two days for decision. On Sept. 30 the elimination contests will begin at Forbes Field in Pittsburgh and will continue until only the winning teams are left for the final championship contests, which will take place on Oct. 1 immediately after the elimination trials are completed.

The different laboratories of the bureau have been completely equipped for the investigation of the various problems relating not only to greater safety, but also to greater efficiency in the mining and metallurgical industries. Visitors will be invited to the electrical and mechanical workshops and laboratories of the bureau and also to the petroleum, gas and coal laboratories, the testing gallery of the mine safety section, and the industrial gas-mask division. Another point of interest will be the experimental mine of the bureau at Bruceton, Pa., twelve miles from Pittsburgh, where an actual explosion of coal dust in the mine will be staged for the benefit of those attending. At the experiment station there is also to be shown a complete exhibit representing the mining and metallurgical industries of the country.

April Imports and Exports

The Bureau of Foreign and Domestic Commerce of the Department of Commerce reports for April, 1919:

DOMESTIC EXPORTS OF CAUSTIC SODA AND SODA ASH FROM U. S. TO ALL COUNTRIES

Countries	Caustic Soda — Lb.	Caustic Soda — Value	Soda Ash — Lb.	Soda Ash — Value
Belgium	91,212	$3,175	.....	....
Denmark	1,026,560	36,900	.....	....
France	760	40	.....	....
Greece	129,366	4,390	.....	....
Iceland and Faroe Islands	550	30	.....	.....
Norway	168,925	7,438	.....	.....
Spain	357,462	16,399	.....	.....
Sweden	.....	.....	439,606	$22,873
British Honduras	.....	.....	95	6
Canada	631,149	29,600	4,387,736	98,124
Costa Rica	10,125	557	.....	.....
Gautemala	762	95	.....	.....
Honduras	19,760	889	.....	.....
Nicaragua	830	24	.....	.....
Panama	28,720	987	760	49
Salvador	.....	.....	1,127	39
Mexico	2,415,071	97,040	480,261	10,736
Newfoundland and Labrador	.....	.....	1,488	33
Trioidad and Tobago	10,700	309	400	16
Other British West Indies (exc. Jamaica and Barbados)	360	32	.....	.....
Cuba	1,098,409	36,055	200,025	4,593
Dutch West Indies	.....	.....	9,000	270
French West Indies	724	38	.....	.....
Dominican Republic	41,000	1,270	3,200	150
Argentina	267,700	12,820	.....	.....
Brazil	722,614	29,789	232,247	9,715
Chile	238,904	8,342	13,590	457
Colombia	56,155	3,957	.....	.....
Ecuador	17,250	528	.....	.....
Peru	8,038	283	21,000	740
Uruguay	167,323	7,043	.....	.....
Venezuela	21,715	914	1,200	72
China	228,712	10,827	.....	.....
British India	112,000	3,416	.....	.....
Dutch East Indies	251,300	10,031	48,125	1,365
Hongkong	150	29	22,395	952
Japan	585,025	23,179	72,000	2,160
Australia	191,410	14,539	24,144	870
New Zealand	31,899	2,274	.....	.....
Philippine Islands	7,750	509	1,000	74
British West Africa	26,880	739	1,300	35
Total	8,967,270	$364,491	5,960,699	$153,329

IMPORTS INTO AND DOMESTIC EXPORTS FROM THE U. S. BY TOTALS ONLY OF COPPER

Exports	Toos	Lb.	Value
Copper ore	.....	.....	.....
Concentrates, matte and regulus	.....	.....	.....
Pigs, ingots, plates, wire, etc., unrefined black, blister and converter copper	.....	.....	.....
Refined copper in ingots, bars or other forms	.....	17,841,731	$3,019,456
Composition, metal, copper chief value	.....	90,125	29,319
Old and scrap	.....	118,084	19,608
Pipes and tubes	.....	574,149	230,739
Plates and sheets	.....	1,299,224	391,917
Wire, except insulated	.....	3,310,788	975,230
All other manufactures of	.....	.....	229,100

Imports	Tons	Lb.	Value
Copper ore	15,187	4,998,467	$978,436
Coocentrates	7,666	1,374,639	374,240
Matte and regulus, coarse metal and cement	2,062	2,400,549	443,899
Manufactures of unrefined black blister and converter copper in bars, pigs or other forms	.....	22,781,489	4,359,543
Refined copper in bars, plates, rods or other forms	.....	556,305	83,445
Old and clippings for remanufacture	.....	175,604	22,953
Composition metals, c pper chief value	.....	2,323	232

Alloy Steels for Helmets and Armor

Notes on Steels of Various Compositions and of High Penetrative Resistance Used for Protective Purposes by the American Army—Details of Electric-Furnace and Rolling-Mill Practice Are Presented

By JOHN A. COYLE

EARLY in America's participation in the war, a prominent Pittsburgh District steel company was asked to produce sheet metals for helmets, the principal specification being that a sheet 0.035 in. thick (20 gage) should withstand a .44 Colt bullet with a muzzle velocity of 840 ft. per sec. at a distance of 10 ft., point blank impact. This was successfully met—ballistic tests of this sort denting the finished helmet over a roughly circular spot of 3½ in. diameter to a depth of perhaps one-half inch.

To produce such metal, experiments were first performed upon manganese-vanadium steel produced by the steel company in its own furnaces, and with the following chemical composition:

C	0.40 to 0.50
Mn	0.80 to 1.00
V	0.20

(Silicon, sulphur and phosphorus normal.) Indifferent results attended these efforts, and no helmets were produced of this analysis; seemingly some other alloying element was needed, or else the relative proportion of those used was not exactly right.

Hadfield's Manganese Steel

Slabs of Hadfield's manganese steel (C, 1 per cent; Mn, 12 to 13 per cent) were then procured from an outside manufacturer and sufficient sheets produced to make about 25,000 helmets. Production was slow and uncertain for a variety of causes, however, and this particular material was abandoned as non-commercial. In the first place the slabs were made from converter steel, and differed widely in quality—a very considerable quantity was returned to the maker as worthless. As received at the rolling mills, the slabs had been quenched from 1800 deg. F., after which this manganese steel could be readily rolled in ordinary mills with the heat treatment usually given mild steel. However, as the slab was reduced there was a marked tendency for the edges and corners to curl up, so that when it was necessary to pair two of them together for the final passes, the sheets could not be readily matched. This fact alone was sufficient to start a search for more workable material. A peculiar characteristic of quenched Hadfield's steel is that it shears easily but cannot be cut with ordinary lathe tools or drills. While it can be pressed cold, a limit to such working is soon reached, since it hardens progressively after continued cold work.

Armor of Nickel-Manganese Steel

A nickel-manganese steel was then produced in quantity in a 6-ton Heroult furnace, a unit of the steel company's equipment, from which 106,000 helmets were successfully made without a single rejection. The analysis follows:

C	0.37 to 0.47 per cent
Mn	0.95 to 1.05 " "
Ni	2.00 " "
V	0.15 to 0.25 " "
Si	0.15 to 0.25 " "
P	0.02 max. " "
S	0.02 max. " "

This material worked very readily—the product after annealing being a dead-soft sheet which could be bent flat upon itself in any direction without sign of fracture. No difficulty was experienced in the sheet mills when following the usual mild-steel practice; the final workable annealing was done in pots at 1700 deg. F. for 10 hours, cooling in the furnace requiring 14 hours to reach 60 deg. F. In such condition the sheets could be readily straightened and trimmed after ordinary methods.

An Indiana enameling and stamping company shaped the helmets to pattern provided by the Government. Originally it was intended to do this in four operations, each separated by an annealing in a continuous furnace some 26 ft. long, heated by side gas-burners to a degree just below recalescence. Passage through this furnace required 3 min., and such treatment apparently relieved any cold-working strains entirely. About 2000 helmets were made in this manner, when experiments demonstrated that the entire shaping could be done in one draw without endangering the impact resistance of the finished helmet. The balance were made in that manner, therefore, the annealing for strain described above being followed by oil quenching from 1500 deg. F., and drawing in oil at 450 deg. F., which practice produced a satisfactory helmet. Another contractor ruined a few of these helmets by a little heat during a sanding and baking operation, but this practice was soon remedied.

With the problem of commercial production of helmets solved, attention was next turned to an armor required by the army, which, when 0.175 in. thick, would resist penetration by a copper covered bullet from a Springfield rifle (muzzle velocity 2140 ft. per sec., range 50 yd.). Some of this specification was produced from metal with the analysis first given—that is, 0.45 carbon, 0.90 manganese and 0.20 vanadium—but apparently a little variation in the chemical composition had a disproportionate effect on the ballistic results. After trials it seemed that higher manganese acted somewhat as a stabilizer, and the following analysis was adopted:

C	0.37 to 0.47
Mn	0.95 to 1.05
Ni	1.85 to 2.15
V	0.15 (as a scavenger)
Si	0.15 to 0.25
P	0.02 max.
S	0.02 max.

Such material appeared satisfactory from many angles

and its quantity production was under way upon the termination of hostilities; in all 9000 tons were made by the company in question.

Melting in Electric Furnaces

As noted, the bulk of this special sheet was made in a 6-ton Heroult electric furnace, which is an ideal producing unit for making ferrous alloys of highest purity. Owing to the pressing demand, an available crucible furnace was also utilized, 24 pots of melted steel and one-half pot of liquid ferromanganese were mixed in a pre-heated ladle before casting into ingots. This was merely an expedient, however, since nearly all of this special metal was made in an electric furnace, a brief description of whose operation may therefore be of interest.

Assuming that the furnace has been fettled after a previous heat, solid charge is placed through the side doors with all possible speed, some 45 min. being required at the best. The load consists of approximately:

1700 lb. wash metal (low-phosporus pig with 3½ per cent C)
6000 lb. low-phosphorus steel scrap
5200 lb. commercial mill-scrap
A varying quantity of ferromanganese
A varying quantity of nickel, 98 per cent pure
300 lb. lime
45 lb. fluorspar

A 110-volt current is then switched on, the doors closed and melting proceeds. Surges of current in cold charged metals are more than considerable, giving up to 10,000 amperes momentarily, but the bath settles to quietness in 30 min. at most. Various systems of electrode regulation have been tried, each of which produces various results, more or less acceptable. From the time of cessation of surging current due to cold charges, melting requires about 2 hr. 45 min., during which time certain reactions are taking place in the metal, so that when the bath is completely fluid, the charge which originally totaled 1.04 carbon, 0.17 silicon, 0.045 phosphorus and 0.035 sulphur, has been reduced to 0.34 carbon, 0.035 phosphorus, 0.04 silicon and 0.030 sulphur.

Dephosphorization

Dephosphorization then proceeds to completion in a bath of moderate temperature in about 45 min. During this period the current consumption is well balanced on the three electrical phases, and while the current input is at maximum of about 450 kw. per phase, the just-melted metal, of course, takes up the heat gradually, and it is during this increase in temperature that the phosphorus is eliminated. When the temperature rises till the optical color appears, which is a white heat above pale yellow, dephosphorization ceases.

Temperature in the furnace is controlled by the eye of an experienced melter combined with his knowledge of the influence of electrical input—a method leaving much to the "personal equation" and capable of large improvement. Unfortunately, however, pyrometric science has not yet solved the problems presented by the electric furnace. Its heat is derived from radiation from an intensely hot arc, and consequently the interior is far from the black body condition demanded by optical pyrometers, while the presence of oxides or carbon films on the slags changes the emissivity factor of the bath continually. The best indication of a furnace's performance during the dephosphorization stage yet found and practiced is a continuance of the ancient slag test—a button of slag after quenching exhibits a peculiar black color and rather indescribable luster, which when recognized is a sign of good work. This physical indication is immediately confirmed by rapid chemical analysis, which is constantly the furnace operator's guardian angel.

When dephosphorization is complete, the metal will have the following approximate composition:

C	0.300	per cent
Si	0.050	" "
P	0.015	" "
S	0.025	" "

The furnace is then tilted slightly and the slag carefully and completely skimmed off through the tapping spout with the aid of wood and metal rakes. Here a word about furnace lines may be apropos. It is well

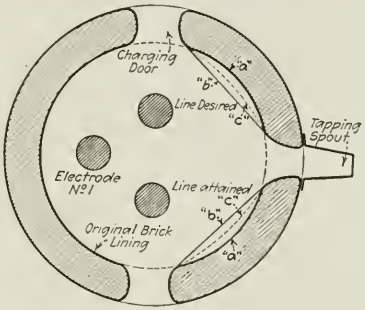


FIG. 1. SKETCH OF HEARTH OF ELECTRIC FURNACE (SECTION THROUGH SIDE WALLS)

known that if any phosphorus-bearing slag or other material remains in the furnace, the phosphorus will reenter the metal at the high temperature reached during desulphurizing, yet little attention in many so-called furnace "designs" is given to the practical problem of making all parts of the bath and banks easily accessible to the skimmer. Thus, an ordinary Heroult furnace may have side walls built somewhat similar to those shown at *a* in the accompanying sketch (Fig. 1). It is readily seen that the little bay formed between charging door and spout is almost inaccessible to the skimmer, and little shelflike crusts of slag are liable to remain in this relatively cool part of the furnace, submerged slightly in the metal, with disastrous results to the final analysis. Proper attention to banking up the side walls with granular fettling may bring them out to the line shown at *b*, but normally the best that can be continually maintained in commercial practice would be some intermediate and rather unsatisfactory mean position such as *c*.

Desulphurization

After the skimming operation, which requires about 15 min., the doors are opened long enough to charge in a few shovelfuls of ingredients for the carbide slag. This is composed primarily of lime, fluorspar and crushed coke, with a little washed silica sand (free from alumina) added to intensify the deoxidation necessary to the proper desulphurizing action of carbide. Desulphurization requires between 60 and 90 min. at a very high temperature. After charging and superheating this slag, the current is reduced to about 80 per cent of maximum input, so that the arc may disturb the

bath as little as possible, since the desulphurizing slags act best after rabbling in, under quiescent mass conditions.

As before, the best quick indication of the desulphurization progress is had by eye examination of slag tests—a proper slag should be pure white above gray, and the quenched piece should give a clear odor of acetylene, indicating the presence of carbide. Such slags need constant attention, building them up as necessary by further additions of their ingredients. Little if any of the pulverized coke enters the metal bath as such to influence its carbon content, since it floats on top the slag layer and continually forms the calcium carbide required for desulphurization.

During this stage the metal is sampled at short intervals and a series of chemical analyses indicate the course of the carbon and manganese elimination. Preliminary nickel assays are also made, although little trouble is experienced with this element—practically 100 per cent recovery of the metal charged at any stage is had. Indeed, it may be remarked in passing that alloying elements (other than deoxidizers and scavengers) may be recovered almost quantitatively by proper attention to melting practice and by protecting with high-lime slags. Even tungsten can be retained in remelting tool scrap if high temperatures are used. An exception to this statement is chromium, which slags readily. Of course, a large loss in manganese is to be expected—only about one-half of that added as ferro remains in the metal.

When desulphurization has proceeded well toward completion (final metal should contain but 0.015 to 0.020 per cent), the proper ferros are added to produce a correct alloy, and very hot metal quickly poured, allowed to stand in the ladle only long enough for the slag to liquate, and then poured into ingot molds. The ingots themselves are 8 in. by 14 in. in cross-section, and are cast in metal molds, split longitudinally and with the usual side lugs for clamping the halves together. A short rectangular sinkhead is placed on the mold, which is top-poured in about 50 seconds. As soon as a sufficiently strong skin has chilled on the hot ingot the molds are opened so that during subsequent cooling there may be no strains in the ingot from the shrinkage in length, top to bottom.

The teeming ladle retains no skull of any sort, a characteristic of hot electric-furnace metal, quickly cast. This is one of the main points of difference in open-hearth and electric steel—the former requires a fairly high silicon (0.20 to 0.35 per cent) to quiet the metal over a slow pouring period. Electric steel should be quiet in the furnace before tapping; silicon in it at 0.06 to 0.07 produces metal with higher physical characteristics than at the open-hearth minimum, and even this low amount is only used to produce a homogeneous metal by reducing a tendency toward segregation.

After pouring the bath, the furnace doors are opened and the lining repaired by fettling through the side doors. For this work a patented refractory—double calcined dolomite sold under various trade names—gives good satisfaction. It is banked up against the side walls in the ordinary manner, an especially large amount being required at the rear wall around No. 1 electrode, the hottest part of the furnace.

One may here remark about the present exorbitant cost of refractories in the making of highest grade electric steels. Whereas the refractory cost early in 1917 amounted to about $1.25 per ton, late in 1918, by the combined action of increase in price and decrease in quality, the cost had jumped to $5.50. Electric-furnace men will therefore naturally welcome a return to prewar conditions among the refractory makers.

Technical and trade literature often bears the statement that electric steel of the nature described in this article can be marketed in commercial quantities at a small differential over open-hearth. This is not true. The differential required today is no less than $25 per ton. With the stabilization of public service electrical supply and other industrial conditions, this spread will be narrowed, but at present even a greater increase in price is needed and is actually justified by the improved service of electric over open-hearth steel. This will become increasingly apparent as engineers fix their minds upon cost per year or cost per unit of service rather than upon first cost.

To recapitulate, the time required for one heat may be tabulated approximately as:

Charging	45 min.
Melting	2 hr. 45 min.
Dephosphoring	45 min.
Skimming	15 min.
Desulphurizing	1 hr. 15 min.
Pouring and fettling	15 min.
Total	6 hr.

Thus about four heats are produced from cold scrap every 24 hours at a current consumption of from 750 to 825 kw.-hr. per ton. Always bear in mind, however, that this figure is for a ton of high-grade steel poured. Common remelted steels or non-purified melts of inconstant composition take less current and give correspondingly less perfect results. The time of refining is materially increased by the necessity of making several chemical analyses during the last stages, especially if the furnace is to be caught and poured as the carbon or manganese is coming down. Otherwise the bath may be built up in the last stages to any desired composition. In this, metallurgical practice is not materially different from standardized open-hearth manipulation.

Pittsburgh, Pa.

Chemists' Club Scholarships

The announcement is made by the scholarships committee of the Chemists' Club of New York, that the Bloede and the Hoffmann scholarships will be awarded for the academic year 1919-1920. These scholarships were founded by Dr. Victor G. Bloede of Baltimore, and Mr. William F. Hoffmann of Newark, with the object of giving financial assistance to deserving young men to obtain an education in the field of industrial chemistry or chemical engineering.

These scholarships will be open to properly qualified applicants without restriction as to residence, and may be effective at any institution in the United States designated or approved by the scholarships committee.

Applicants must, as a minimum qualification, have completed a satisfactory high school training involving substantial work in elementary chemistry, physics and mathematics, and present a certificate showing that they have passed the entrance examination requirements of the college entrance examination board or its equivalent.

All inquiries should be addressed to the Scholarships Committee, Chemists' Club, 52 E. 41st St., N. Y.

Nodulizing Flotation Concentrates in a Rotary Kiln With Powdered Coal

By Robert M. Draper

THE rotary kiln has long been used in the cement industry, but only recently has it been utilized in the metallurgy of copper.

In September, 1912, a small 60-ft. kiln was installed at the plant of the United States Metals Refining Co. at Chrome, N. J., for the purpose of nodulizing a large accumulation of flue dust. The kiln proved a success from the start, and after the accumulated flue dust was used up, flotation concentrates were nodulized into a very satisfactory blast-furnace product. Several years later kilns were installed at Braden and operated very successfully on flotation concentrates. Both of these installations used fuel oil and at the time considerable doubt was expressed whether the operation would be successful with powdered coal on account of the low temperature required.

In 1917 the Canada Copper Corporation, Ltd., in developing its large low grade copper property at Copper Mountain, British Columbia, found that it was going to have a large amount of high grade flotation concentrates to sell and came to the conclusion that perhaps nodulizing would be of advantage. Oil for fuel was out of the question, and as there was a cement kiln in the vicinity of the mine with all the facilities for pulverizing the coal, it was decided to try some experiments with this equipment.

Two Main Problems

There were two main problems: First, to put the flotation concentrates in shape physically for the blast-furnace and second, to retain as much of the sulphur as possible. The kiln used was the usual type in cement practice, 125 ft. long and 7 ft. diameter inside of the brick work, and was in very good shape. The coal dust machinery was designed to furnish a much larger volume than was necessary for nodulizing flotation concentrates, but could be regulated fairly satisfactorily by means of a slide in the discharge pipe.

The method in use for feeding the concentrates into the kiln at Chrome had been by a screw conveyor, but this had not proved entirely satisfactory owing to choking the conveyor, and we decided to try hoisting the concentrates up to the feed end of the kiln by a bucket elevator and chuting them down into the kiln through a pipe. Owing to the original design of the plant a slope of 60 deg. was all that could be obtained for this pipe and we had more or less trouble with choking. It required a man constantly to poke the concentrates down the pipe, while the bucket elevator also gave trouble with choking.

Three Flotation Concentrates Used

For the experiments three different kinds of flotation concentrates were used: Highland Valley flotation concentrates, Highland Valley table concentrates, and Copper Mountain concentrates. Assays were as follows:

	Cu	SiO_2	Fe	CaO	S
Highland Valley flotation concentrates	19.25	19.2	18.7	2.0	18.0
Highland Valley table concentrates....	21.65	19.0	25.1	1.7	19.0
Copper Mountain concentrates.....	26.57	20.0	15.8	3.9	18.7

The copper was present in all three ores principally as bornite and chalcopyrite.

To retain as large a percentage of sulphur as possible several different schemes were tried. A spray pipe was run down into the feed end of the kiln for a distance of 6 ft. and a spray of water used to keep the concentrates as wet as possible so they would not have a chance to roast before reaching the nodulizing zone. The discharge end of the kiln was kept as nearly hermetically sealed as possible to prevent the entrance of air, but it was found extremely difficult to obtain this condition. A damper was placed in the stack and kept open just sufficiently to permit the gases to escape while keeping the kiln full of the fumes from the concentrates at all times. We found no trouble in regulating this damper so that a small amount of fume backed out of the feed end of the kiln at all times but at no time in sufficient quantity as to be obnoxious.

Best Method Not Determined

The amount of material to experiment with was not sufficient to determine which of these methods was the most satisfactory, but I am inclined to believe the damper in the stack is much the more efficient, as there can be very little tendency to draw air into a kiln that is so choked that fumes back up at both ends. Hermetically sealing the discharge end would of course give the same result, but this is very hard to do in actual practice.

How much good the spray pipe at the feed end accomplished I do not know, but I believe it would have an important bearing in reducing the dust losses.

No trouble was experienced from the start in making a very satisfactory nodule from a physical standpoint, the majority varying from $\frac{1}{4}$ to $\frac{1}{2}$ in. in diameter, and hard enough to withstand quite a sharp blow with the hammer.

Analysis of Samples

Careful samples of all tests were taken and sent to the smelter at Greenwood for analysis. These samples showed that we were retaining 70 to 80 per cent of the original sulphur. In one case when the nodules were giving off dense fumes of sulphur as they were discharged from the kiln the sample was split and half allowed to cool slowly in the air and half plunged immediately into water. The sample that was air cooled showed practically as much sulphur as that cooled in the water. This fact is important, as the nodules show a decided tendency to break up if cooled with water, but they could be readily cooled by passing them along a revolving cylinder.

The coal used was from mines in the vicinity—a rather poor bituminous coal carrying 20 per cent ash. No trouble was experienced in keeping the coal ignited, in fact several times after an hour's shut-down the coal was turned on and ignited without extra fuel of any sort.

We found no difficulty in nodulizing five tons of concentrates per hour with a coal ratio of 1 to 15.

The action all the way through was very similar to nodulizing with fuel oil. No trouble was experienced from the formation of accretions upon the walls of the kiln, and those that did form were within 12 or 15 ft. of the discharge end of the kiln, where they could be easily reached and barred off. There did not seem to be any excessive dust losses. Only 2 per cent of the amount fed settled in the chamber at the base of the stack, and the stack itself at no time gave any indications of excessive losses. There is no doubt in my mind that nodulizing in the rotary kiln with powdered coal will be as successful as in installations using fuel oil.

Southboro, Mass.

Notes on the Influence of Certain Variables Associated With the Anneal of Cold-Worked Alpha Brass

Degree of Plastic Deformation—Temperature and Time of Anneal—Rate of Heating Through the Germinative Temperature—Size and Uniformity of the Grains Prior to the Plastic Deformation—Potential Possibilities of Rolled Metal

By ARTHUR PHILLIPS* and GEORGE C. GERNER*

ONE of the first papers[1] to deal with the characteristics of recrystallization and grain growth of cold-worked alpha brass on annealing pointed out that different degrees of plastic deformation materially affected the initial temperature of visible recrystallization and also the size of the recrystallized grains. Later writers, notably Jeffries[2] and Howe[3], in discussing this paper, have presented what seem to be the main factors having a controlling influence over the mechanism of recrystallization and grain growth of pure metals and solid solutions.

It may not be out of place to review briefly the principal variables which have a pronounced effect on the mechanical properties and microstructure of commercial alpha brass on anneal subsequent to cold-reduction.

1. Degree of Plastic Deformation

In a paper[1] previously mentioned, it has been shown that different degrees of plastic deformation have a very decided influence on the temperature of recrystallization. In general, other conditions being the same, the greater the cold-reduction the lower the temperature of visible recrystallization. As evidence of this, the authors found that an anneal between 275 and 300 deg. (30 min.) following a reduction of 40 per cent sufficed to cause incipient recrystallization; the same brass reduced only 4 per cent required an anneal at 650 deg. to produce positive structural evidence of re-orientation. Furthermore, the size of the recrystallized units decreased progressively with increase in the degree of plastic deformation. Bassett and Davis, in a recent paper[5] showing the relation between the grain size and Brinell hardness of cartridge brass, have also shown that the grain size of brasses annealed at the lower temperatures is greatly affected by the degree of reduction.

2. Temperature and Time of Anneal

As stated in the preceding paragraph, the temperature of recrystallization of brass may extend over a very considerable temperature range depending upon the degree of deformation to which the metal has been subjected. Characteristic curves showing the grain size and mechanical properties as a function of the temperature (for a given reduction and constant period of anneal) show how necessary it is, from the practical standpoint, to give careful attention to the annealing temperature if specific properties are desired.

With regard to the effect of time of anneal, it is a matter of general knowledge that in the case of rather severely worked brass, i.e., corresponding to an ordinary mill reduction, the time factor is of great importance when the annealing temperature is within the range of incipient recrystallization. For higher temperatures, when approximate equilibrium conditions are rapidly attained, the question of time, between rather broad limits, is of less importance. Although this is, perhaps, a matter of common knowledge, it seems desirable to include in this paper experimental data which show the effect of time of anneal at 650 deg. on the tensile strength of alpha brass having various reductions. It is to be understood, however, that the experimental data have simply been taken bodily from the results of an investigation carried on with another objective in view. For this reason, we ask indulgence for one or two features connected with the experimental procedure which do not seem to be consistent with the subject under consideration.

For the experiments we selected from the same coil several strips of cartridge brass†, 4 in. wide and 0.185 in. thick, which had been given a uniform reduction of 43 per cent by cold-rolling in the mill. The strips were annealed together in an American gas furnace at 700 deg. for one-half hour, with a preheating period of 10 minutes. The temperature data were obtained by means of a carefully calibrated base-metal pyrometer.

Following this laboratory anneal, four strips were given mill reductions of 6.6, 15, 25 and 40 per cent respectively. Six test pieces, 8 in. by 1 in., were cut from each strip and the twenty-four bars were divided into six sets of four pieces; each set representing reductions from 6.6 to 40 per cent. The total charge was then placed in a rectangular muffle, wound with nichrome ribbon, and annealed at 650 deg. Temperature measurements were made by means of a platinum-rhodium couple, inserted in a hole drilled into the end of one strip, used in conjunction with high-resistance galvanometer. The long preheating period, 1 hr. and 7 min., was due to the mass of metal in the furnace.

A set of test bars was removed at successive intervals in the following order: end of preheating period (i.e., 1 hr., 7 min.), 15 min., 30 min., 1 hr., 2 hr. and 5 hr. After carefully milling the bars to a width of 0.50 in. over a gage length of 3 in., they were tested in a 50,000-lb. Riehle universal testing machine. The

*Metallurgical Department, Bridgeport Brass Co.

[1] Mathewson & Phillips: "The Recrystallization of Cold-Worked Alpha Brass on Annealing," *Trans.*, Amer. Inst. Min. Eng., 1916, Vol. 54, p. 608.

[2] Jeffries: Discussion of above paper, p. 658.
Jeffries: "Grain Growth Phenomena in Metals," *Trans.*, Amer. Inst. Min. Eng., 1916, Vol. 56, p. 571.

[3] Howe: "Recrystallization After Plastic Deformation." *Trans.*, Amer. Inst. Min. Eng., 1916, Vol. 56, p. 561.
Howe: "On Grain Growth," *Trans.*, Amer. Inst. Min. Eng., 1916, Vol. 56, p. 583.

[4] Mathewson & Phillips, *loc. cit.*

[5] Bassett and Davis: "A Comparison of Grain-size Measurements and Brinell Hardness of Cartridge Brass," *Trans.*, Amer. Inst. Min. Eng., February meeting, 1919.

†Analysis: Copper, 70.24; iron, 0.023; lead, 0.014 per cent.

testing data are tabulated in Table I and plotted in Fig. 1. Although we were unable to make these tests in duplicate, due to limited furnace capacity, we believe that the results are fairly reliable and significant. Samples for microscopic examination were retained, but, unfortunately, the reproduction and discussion of the micrographs is not possible in this paper.

A study of these data seems to indicate that at 650 deg. a measurable length of time is necessary to produce apparent equilibrium values for all reductions investigated. In the case of the brass reduced 40 per cent, continued annealing up to 2 hr. was attended with lower tensile strength. Since the value of the tensile strength after a 2-hr. anneal is practically identical with that found after a 5-hr. anneal, it seems reasonable to conclude that, from the practical standpoint, approximate equilibrium conditions are obtained after the shorter period. A repetition of this work will, of course, be necessary before final conclusions can be drawn regarding the effect of time of anneal on the mechanical properties of rolled brass. For this reason we do not think it advisable to enter into a lengthy discussion of the magnitudes involved, but simply offer the testing data for their possible suggestive value.

TABLE I—EFFECT OF TIME OF ANNEAL (AT 650 DEG. C.) ON TENSILE STRENGTH OF COLD-WORKED ALPHA BRASS

Per Cent Reduction	Time at Annealing Temperature	Original Size Dimensions, Inches	Area, Sq.In.	Breaking Weight	Tensile Strength, Lb.sq.In.
6.6	Unannealed	0.168x0.755	0.1270	6000	47,300
15.5	Unannealed	0.152x0.744	0.1131	5980	53,000
25.0	Unannealed	0.136x0.750	0.1020	6120	60,000
40.0	Unannealed	0.108x0.753	0.0813	6000	73,800
6.6	0	0.503x0.168	0.0845	3850	45,600
6.6	15 minutes	0.500x0.166	0.0830	3790	45,700
6.6	30 minutes	0.499x0.168	0.0838	3790	45,250
6.6	1 hour	0.497x0.167	0.0830	3780	45,600
6.6	2 hours	0.471x0.168	0.0792	3560	45,000
6.6	5 hours	0.487x0.167	0.0813	3650	44,900
15.5	0	0.503x0.150	0.0754	3560	47,200
15.5	15 minutes	0.503x0.150	0.0754	3510	46,500
15.5	30 minutes	0.509x0.150	0.0764	3550	46,500
15.5	1 hour	0.502x0.151	0.0757	3520	46,450
15.5	2 hours	0.508x0.151	0.0767	3550	46,300
15.5	5 hours	0.507x0.151	0.0765	3500	45,750
25.0	0	0.500x0.132	0.0660	3150	47,750
25.0	15 minutes	0.503x0.133	0.0669	3140	46,950
25.0	30 minutes	0.500x0.132	0.0660	3100	47,000
25.0	1 hour	0.498x0.133	0.0662	3070	46,400
25.0	2 hours	0.506x0.132	0.0668	3100	46,400
25.0	5 hours	0.496x0.133	0.0660	3020	45,800
40.0	0	0.471x0.107	0.0503	2410	47,850
40.0	15 minutes	0.496x0.108	0.0538	2540	47,250
40.0	30 minutes	0.494x0.108	0.0533	2490	46,700
40.0	1 hour	0.490x0.107	0.0524	2410	46,000
40.0	2 hours	0.473x0.107	0.0506	2310	45,650
40.0	5 hours	0.491x0.107	0.0525	2400	45,700

3. Rate of Heating Through the Germinative Temperature

Jeffries[6] has shown that in the case of pure metals and solid solutions reduced at least 15 per cent by cold-work, the grain size equilibrium (for any temperature above the equiaxing range) depends largely on the rate at which the metal passes through the equiaxing range. In general, the faster the metal is heated through this range the smaller will be the equilibrium grain size; conversely, the greater the lag in passing through the equiaxing temperature the greater the equilibrium grain size. Grain size equilibrium is defined by Jeffries as "the point where grain size either changes none or slowly." In other words, there is a small temperature range, i.e., the "germinative temperature," for every reduction at which grain growth is particularly marked. The period during which the metal is at the "germinative temperature," as remarked above, is an important factor regulating the early stages of grain growth. Although the rate of heating, in the case of alpha brass, may, under special and exceptional conditions, have an important effect on its structure and properties, yet in ordinary mill practice, which generally involves a moderately high temperature of anneal following a rather high degree of plastic deformation, considerable latitude may be allowed in the rate of heating without materially affecting the characteristics of the anneal.

4. Size and Uniformity of the Grains Prior to the Plastic Deformation

Jeffries[7] remarks in this connection that "in a given pure metal with a given amount of cold deformation, the grain size before deformation will have a marked effect on the selective grain growth during anneal. If the initial grain size is large, the grain fragments formed during annealing will be correspondingly large, and if the initial grain size is small the grain fragments will also be smaller than in the previous case." Also, "when the total average cold deformation exceeds 30 to 40 per cent reduction in area of the metal, the number of germinative grains formed during normal muffle heating may approximately equal the number of equilibrium grains for the maximum temperature reached during annealing, and thus the metal is said to be fine grained." On the other hand, if the cold deformation is comparatively slight, the local strain gradients resulting produce comparatively few germinative grains which, during the

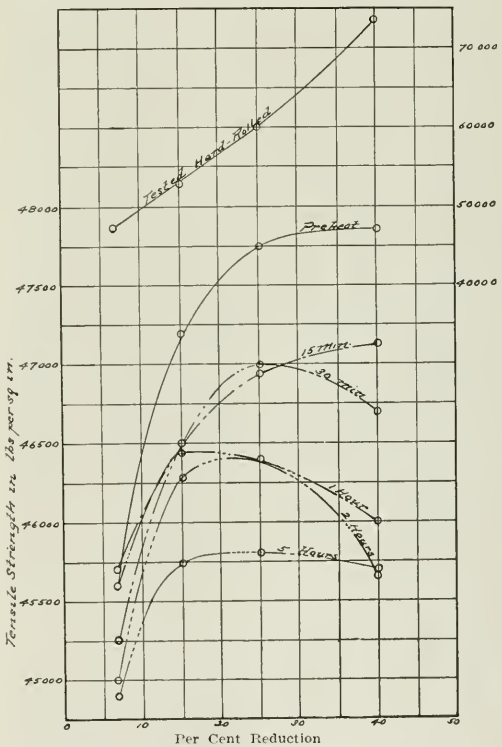


FIG. 1. EFFECT OF TIME OF ANNEAL (650 DEG. C.) ON TENSILE STRENGTH OF COLD-WORKED ALPHA BRASS

[6]Jeffries: Amer. Inst. Min. Eng., 1916, Vol. 54, p. 660.

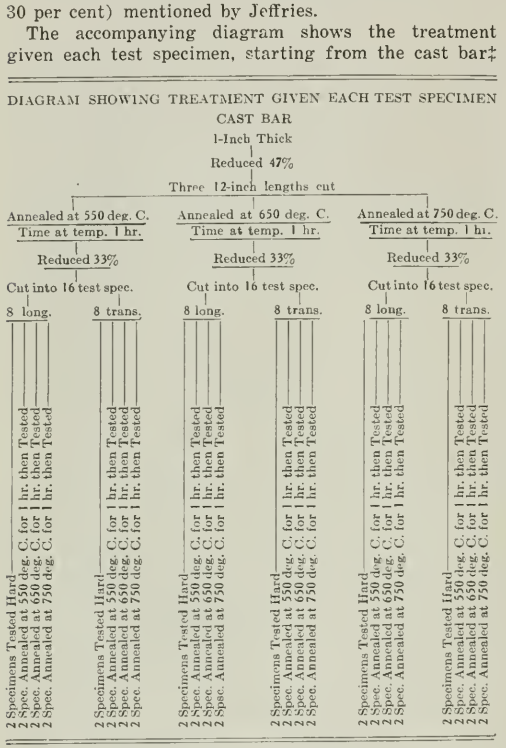
[7]Jeffries: Amer. Inst. Min. Eng., 1916, Vol. 56, p. 575.

subsequent anneal, attack and absorb the inert grains. Such treatment tends to favor "selective grain growth" and is characterized by coarse crystallization.

In order to learn the influence of the grain size prior to the plastic deformation on the microstructure and mechanical properties of rather severely worked alpha brass annealed under conditions comparable to mill practice, the following experimental work was undertaken. It should be noted that the reduction given the metal used in this investigation exceeded the minimum value (i.e., 30 per cent) mentioned by Jeffries.

The accompanying diagram shows the treatment given each test specimen, starting from the cast bar‡

DIAGRAM SHOWING TREATMENT GIVEN EACH TEST SPECIMEN



(1.0 in. thick) to the testing of the pieces. As indicated by the diagram, the cast bar was reduced 47 per cent, cut in 12-in. lengths, three of which were used for this experimental work. One piece was annealed at 550 deg., another at 650, and the third at 750. In all cases the period of anneal was 1 hr.; the preheat period varied from 15 to 40 min. All anneals were made in an American gas furnace. After the anneals the strips were reduced 33 per cent by cold-rolling in the mill. Each piece was then cut into sixteen test specimens, eight in the direction of rolling and eight at right angles to the direction of rolling. This gave six lots of samples, eight in each lot. All strips were milled so as to give a test section 4¼ in. long, with a cross-sectional area 0.625 in. times the thickness of the metal (0.355 in.).

Each lot was again divided into four sets, two to a set. One set from each lot was tested hard; the remaining three sets were annealed for 1 hour at 550, 650 and 750 deg. respectively. A piece for microscopic examination was cut from the end of each test piece.

‡Analysis: Copper, 70.33; iron, 0.018; lead, 0.005 per cent.

Tensile and hardness tests were made on each specimen. The scleroscopic tests were made with a Shore instrument; an Olsen (hydraulic type) machine was used in determining the Brinell hardness. Two indentations were made on each test piece, one at each end, and the average value given. The indentations on the unannealed test pieces were, of course, elliptical. For this

TABLE II—EFFECT OF GRAIN SIZE PRIOR TO PLASTIC DEFORMATION ON TENSILE PROPERTIES OF ANNEALED ALPHA BRASS

(Longitudinal Tests)

Temp. of Final Anneal	Tensile Strength Lb. Per Sq.In.	Per Cent. Elong. in 2 in.	Per Cent Red. Area	Hardness Brinell No.	Hardness Scler. No.	Grains Per Sq.In. at 50×
Annealed at 550 deg. C. before last reduction.						
Unannealed	75,400	18.5	51.7	143	33–35	.....
Unannealed	75,900	18.0	51.9	143	33–35	.....
Average	75,650	18.25	51.8	143	34	.....
550 deg. C.	48,300	69.0	70.8	63	11–12	.....
550 deg. C.	50,100	66.0	67.0	63	11–12	169.0
Average	49,200	67.5	68.9	63	11.5	.....
650 deg. C.	45,950	69.0	72.6	54	10	.....
650 deg. C.	47,600	72.0	70.3	54	10	.....
Average	46,780	70.5	71.4	54	10	57.8
750 deg. C.	43,450	77.5	67.5	45	8	.....
750 deg. C.	43,820	76.0	64.9	45	8	.....
Average	43,640	76.8	66.2	45	8	13.2
Annealed at 650 deg. C. before last reduction						
Unannealed	74,800	19.0	53.2	143	33–35	.....
Unannealed	74,900	17.0	56.8	143	33–34	.....
Average	74,850	18.0	55.0	143	34	.....
550 deg. C.	48,400	72.0	73.5	57	11	.....
550 deg. C.	47,700	70.0	74.0	59	11	.....
Average	48,050	71.0	73.75	58	11	89.0
650 deg. C.	45,620	75.0	74.4	50	10	.....
650 deg. C.	44,650	73.0	74.8	52	10	.....
Average	45,850	74.0	74.6	51	10	36.0
750 deg. C.	42,650	80.0	70.2	43	8	.....
750 deg. C.	43,180	80.5	69.4	45	8	.....
Average	42,900	80.3	69.8	44	8	8.5
Annealed at 750 deg. C. before last reduction						
Unannealed	68,800	24.0	50.2	136	31	.....
Unannealed	67,100	24.0	52.8	130	30	.....
Average	67,950	24.0	51.5	133	30.5	.....
550 deg. C.	47,150	73.0	71.9	57	11	.....
550 deg. C.	47,200	75.0	75.6	57	11	.....
Average	47,175	74.0	73.7	57	11	45.0
650 deg. C.	47,700	77.5	68.7	50	10	.....
650 deg. C.	44,200	80.5	74.3	50	10	.....
Average	44,900	79.0	71.5	50	10	21.5
750 deg. C.	42,100	85.0	70.1	44	8	.....
750 deg. C.	42,280	89.0	70.7	43	8	.....
Average	42,190	87.0	70.4	43.5	8	3.6

TABLE III—EFFECT OF GRAIN SIZE PRIOR TO PLASTIC DEFORMATION ON TENSILE PROPERTIES OF ANNEALED ALPHA BRASS

(Transverse Tests)

Temp. of Final Anneal	Tensile Strength Lb. Per Sq.In.	Per Cent Elong. in 2 In.	Per Cent Red. Area	Hardness Brinell No.	Hardness Scler. No.	Grains. Per Sq.In. at 50×
Annealed at 550 deg. C. before last reduction						
Unannealed	77,800	11.0	27.8	158	33–35	.....
Unannealed	78,200	12.0	21.7	158	33–35	.....
Average	78,000	11.5	25.1	158	34	.....
550 deg. C.	49,900	66.0	58.7	63	12	.....
550 deg. C.	49,300	62.0	60.0	63	11	.....
Average	49,600	64.0	59.3	63	11.5	169.0
650 deg. C.	45,900	71.0	66.5	54	10	.....
650 deg. C.	45,900	71.0	61.5	54	10	.....
Average	45,900	71.0	63.9	54	10	57.8
750 deg. C.	43,050	76.0	62.4	45	8	.....
750 deg. C.	42,620	77.5	65.7	45	8	.....
Average	42,800	76.8	64.0	45	8	13.2
Annealed at 650 deg. C. before last reduction						
Unannealed	75,200	13.0	32.2	158	33–34	.....
Unannealed	75,400	9.0	27.8	158	34–35	.....
Average	75,300	11.0	30.0	158	34	.....
550 deg. C.	47,300	66.0	50.2	57	10	.....
550 deg. C.	48,900	69.0	50.3	59	10	.....
Average	48,050	67.5	50.25	58	10	89.0
650 deg. C.	45,200	73.0	69.5	50	10	.....
650 deg. C.	45,500	76.0	71.4	50	9–10	.....
Average	45,350	74.5	70.4	50	10	36.0
750 deg. C.	42,280	80.0	69.4	45	8	.....
750 deg. C.	Flaw in sample			44	8	.....
Average	42,280	80.0	69.4	44.5	8	8.5
Annealed at 750 deg. C. before last reduction						
Unannealed	68,100	15.0	28.7	143	30	.....
Unannealed	68,300	9.0	22.2	143	31	.....
Average	68,200	12.0	25.45	143	30.5	.....
550 deg. C.	46,700	68.5	70.7	57	11	.....
550 deg. C.	46,600	69.0	62.7	57	11	.....
Average	46,650	68.75	66.2	57	11	45.0
650 deg. C.	43,200	79.0	73.4	50	10	.....
650 deg. C.	43,820	79.5	71.1	50	10	.....
Average	43,500	79.3	72.2	50	10	21.5
750 deg. C.	Flaw in sample			44	8	.....
750 deg. C.	42,650	82.0	66.5	44	8	.....
Average	42,650	82.0	66.5	44	8	3.6

reason, the axis parallel to the direction of rolling was measured on the longitudinal test pieces; the axis normal to the direction of rolling was measured on the transverse pieces. Tensile tests were made on a 50,000-lb. Riehle universal testing machine. In addition to the tensile strength determinations, values for the per cent elongation and per cent reduction in area were obtained.

Results of the Tests

Table II shows the results of tests made on specimens taken in the direction of rolling; Figs. 2 and 3 present the same data in plotted form. Table III gives the results of tests made on test pieces taken normal to the direction of rolling. As the transverse tests of the annealed samples agreed so closely with the values obtained on the longitudinal tests, it did not seem necessary to plot the results shown in Table III. The average values obtained on the unannealed test pieces, longitudinal and transverse, are given again in Table IV in order that they may be readily compared. It will be noted in Figs. 2 and 3 that the curves show the physical properties as a function of the anneal before the final reduction, instead of the final anneal as is the common practice.

TABLE IV—DIRECTIONAL PROPERTIES OF ALPHA BRASS REDUCED 33 PER CENT BY COLD ROLLING SUBSEQUENT TO ANNEAL AT 550, 650 AND 750 DEG. C., RESPECTIVELY

Temperature of Anneal, Deg. C.	Tensile Strength, Lb. Sq.In.	Per Cent Elongation in 2 In.	Per Cent Reduction of Area
550 Longitudinal	75,650	18.25	51.8
550 Transverse	78,000	11.5	25.1
650 Longitudinal	74,850	18.0	52.6
650 Transverse	75,300	11.0	30.0
750 Longitudinal	67,950	24.0	52.1
750 Transverse	68,200	12.0	25.5

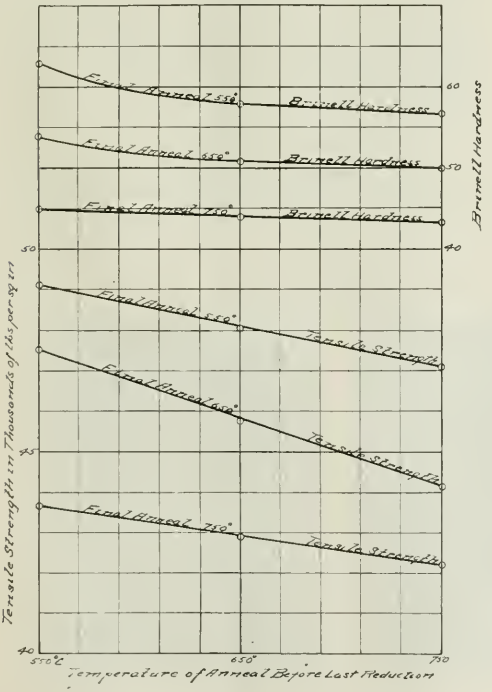


FIG. 2. EFFECT OF GRAIN SIZE PRIOR TO COLD-REDUCTION ON TENSILE PROPERTIES OF ANNEALED ALPHA BRASS (LONGITUDINAL TESTS)

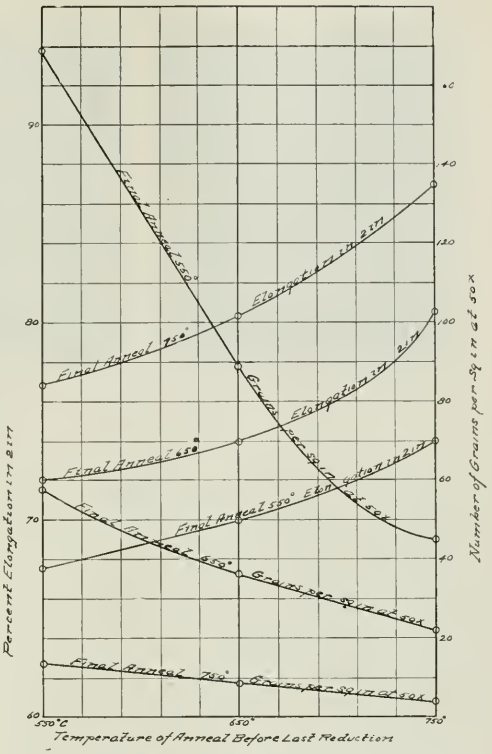


FIG. 3. EFFECT OF GRAIN SIZE PRIOR TO COLD-REDUCTION ON TENSILE PROPERTIES OF ANNEALED ALPHA BRASS (LONGITUDINAL TESTS)

Twelve micrographs, showing the effect of the grain size before plastic deformation on the structure produced by the final anneal, are shown in Plates I, II, III and IV. Grain size measurements (expressed in grains per sq.in. at 50 diameters) are given in Tables II and III and are plotted in Fig. 3.

TABLE V—DIRECTIONAL PROPERTIES OF ALPHA BRASS REDUCED 33 PER CENT BY COLD-ROLLING SUBSEQUENT TO ANNEAL AT 680 DEG. C.

	—Original Size— Dimensions, Inches	Area, Sq.In.	Breaking Weight, Lb.	Tensile Strength, Lb. Sq.In.	Per Cent Elong. in 2 In.	Per Cent Reduction of Area
Longitudinal test bar...	0.610x0.354	0.2159	15,230	70,500	20.0	51.7
Longitudinal test bar...	0.607x0.353	0.2142	15,050	70,300	18.5	49.2
Longitudinal test bar...	0.606x0.352	0.2133	15,050	70,600	19.0	52.9
Average				70,470	19.2	51.3
Transverse test bar....	0.643x0.355	0.2282	16,140	70,700	15.5	35.4
Transverse test bar....	0.620x0.355	0.2200	15,570	70,750	11.0	31.6
Transverse test bar....	0.624x0.355	0.2215	15,620	70,500	12.0	31.7
Average				70,650	12.8	32.9

Tensile tests on the annealed samples indicate that while the grain size before the final reduction has some influence on the mechanical properties of the annealed brass, the magnitude of the effect is small, especially in metal annealed at the higher temperatures. It will be

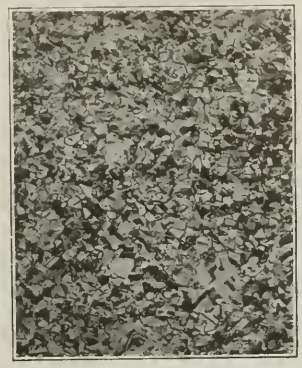


Fig. A. One hour at 550 deg. C.

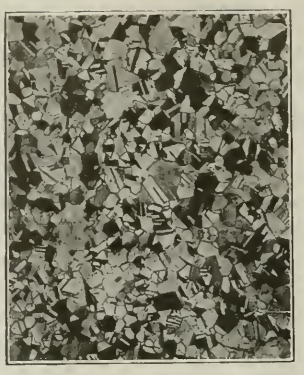


Fig. B. One hour at 650 deg. C.

Fig. C. One hour at 750 deg. C.

PLATE I

Etched with ammonia and hydrogen peroxide. × 50. Cartridge brass (copper, 70.33; lead, 0.005; iron, 0.018 per cent). Effect of anneal after 47 per cent reduction by rolling.

seen from Fig. 2 that the tensile strength curve for 750 deg. final anneal is almost horizontal, indicating that for this anneal the tensile strength is, within certain limits, independent of the previous grain size. The Brinell hardness curve of Fig. 2 and the crystal count curve of Fig. 3 for the same anneal also show very little change, but the curve for per cent elongation in Fig. 3 slopes upward, which seems to indicate that large initial grain size tends to increase the elongation. The same relation seems to hold for the lower temperature final anneals as indicated by the elongation curves of Fig. 3, all of which show about the same slope. In the lower temperature anneals, the smaller initial grain size seems to yield finer grain fragments upon subsequent anneal, as is shown by the crystal count curves in Fig. 3. The tensile strength is also increased as would be expected from the finer grain produced by the anneal.

An examination of the micrographs shown in Plates I, II, III and IV seems to indicate that the grain size prior to reduction is one of the important factors affecting the final grain size. The samples annealed at the higher temperatures show considerable variation in grain size within the individual specimens. This type of structure, as shown by Fig. C, Plate III, and Figs. A, B and C, Plate IV, is quite characteristic of commercial brass. In view of the difficulty of obtaining grain counts with a high degree of accuracy, it does not seem advisable to subject the grain count curves of Fig. 3 to critical analysis. It is evident, however, that in all cases the grain size after all final anneals (i.e., 550, 650, 750 deg.) increased progressively with increase in temperature of the anneal prior to the reduction.

Ductility

As has been previously stated, the annealed brass when tested longitudinally and transversely showed no directional properties; the rolled metal, however, when tested showed that the longitudinal test pieces yielded the higher values of ductility. These values are given in Table IV, from which it will be seen that although the tensile strength is practically the same, there is a very marked difference in the per cent elongation and the reduction of area. The tests become especially intresting when compared with the values given by Price and Davidson[8] for similar tests on common high brass

[8]Price and Davidson: "Physical Tests on Common High Brass Taken Parallel and at Right Angles to the Direction of Rolling" Amer. Inst. Metals, 1916, Vol. 10, p. 133.

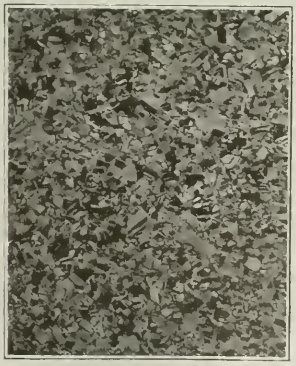


Fig. A. One hour at 550 deg. C.

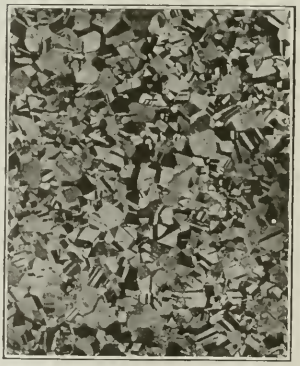


Fig. B. One hour at 550 deg. C.

Fig. C. One hour at 550 deg. C.

PLATE II

Cartridge brass (copper, 70.33; lead, 0.005; iron, 0.018 per cent). Effect of anneal after 33 per cent reduction by rolling. Etched with ammonia and hydrogen peroxide. × 50.

Fig. A. One hour at 650 deg. C.

Fig. B. One hour at 650 deg. C.

Fig. C. One hour at 650 deg. C.

PLATE III

Cartridge brass (copper, 70.33; lead, 0.005; iron, 0.018 per cent). Effect of anneal after 33 per cent reduction by rolling. Etched with ammonia and hydrogen peroxide. × 50.

which had received approximately the same reduction. In this connection they state that "up to 35 per cent reduction by rolling the elongations for both kinds of strips are practically identical. But from there on the transverse specimens show marked superiority."

Since our results were contradictory to this conclusion we annealed another piece of the same bar at 680 deg. and gave it the same reduction, i.e., 33 per cent, after which three longitudinal and three transverse tests were made. The results of these tests are given complete in Table V, and it will be seen that here again the elongation and reduction of area are higher for the longitudinal samples than for the transverse. Although Price and Davidson found no difference at 33 per cent reduction, they found that the elongation was less in longitudinal than in transverse tests in the samples which had been reduced above 35 per cent. This is not in agreement with our results.

Possibly the following explanation may account for the higher ductility of the longitudinal test pieces. Due to the compressive action of the rolls, plastic deformation takes place by means of a series of slips along a large number of gliding-planes or cleavage-planes, most of which are at right angles to the direction of grain extension. The characteristic lines of deformation found in cold-worked brass are very prominent in Price and Davidson's micrographs.

In explaining their results Price and Davidson attributed the poorer ductility of the longitudinal test bars to the fact that the planes of slip (at right angles to the tensile stresses) had been utilized during the rolling operation. When making the transverse tests, however, a large number of gliding-planes would be available, since comparatively few had been utilized during the rolling operation. For this reason, they believed that the transverse test bars should give the greater elongation.

In order to explain the contrary results obtained by us, we would offer a suggestion with regard to the potential possibilities of the rolled metal. Fig. 4 (on the left) represents a test bar cut from metal at right angles to the direction of rolling. Within the individual grains, and chiefly parallel to the length of the test bar, are a very large number of lines of deformation which are indicative of plastic deformation by slip. If, as it is quite generally believed, movement by slip generates amorphous material along the gliding-planes, the test piece is reënforced by innumerable plates of amorphous

Fig. A. One hour at 750 deg. C.

Fig. B. One hour at 750 deg. C.

Fig. C. One hour at 750 deg. C.

PLATE IV

Cartridge brass (copper, 70.33; lead, 0.005; iron, 0.018 per cent). Effect of anneal after 33 per cent reduction by rolling. Etched with ammonia and hydrogen peroxide. × 50.

material of a low order of ductility. It seems reasonable to conclude, therefore, that the presence of these plates would tend to lower the ductility of the mass as a whole when subjected to a tensile force.

Fig. 4 (on the right) represents a test bar cut from the metal parallel to the direction of rolling. In this case the amorphous planes are at right angles to the length of the test section. Although slip has taken

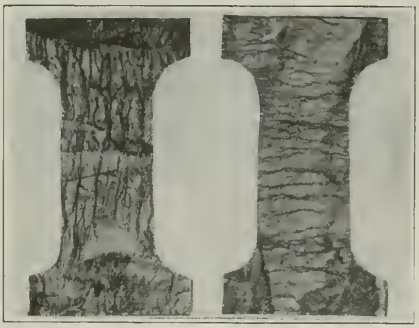


FIG. 4. TEST BAR CUT AT RIGHT ANGLES TO DIRECTION OF ROLLING (LEFT). CUT PARALLEL (RIGHT)

place along a large number of gliding-planes during the rolling operation, there must still remain a very considerable number of gliding-planes along which movement can take place when the bar is subjected to tensile test. That this is true is indicated by Price and Davidson's micrograph, Fig. D, Plate IV, showing the structure of the test piece which had been reduced approximately 80 per cent without fracture.

In other words, we believe the distribution of the amorphous material in the longitudinal test bars is more favorable to extension under tension in the transverse test bars.

In this connection the experimental results given by Price and Davidson do not seem to be at all consistent with their statement: "It is common knowledge that in a cold bend test, a piece of very hard brass can be bent several times through 180 deg. when tested longitudinally. The same specimen when bent transversely will fail before it passes through an angle of 90 deg."

Effect of Sodium Chloride on Blue-Powder Formation

By Reginald S. Dean

IT IS common practice in zinc metallurgy to add small amounts of salt to the charge, which has been definitely found to reduce the amount of blue powder formed. No satisfactory explanation has been offered, however, for this action of sodium chloride, and we are therefore not in a position to develop any improvements in this method of preventing blue-powder formation.

The only text-book which discusses or even mentions the use of salt in Lodin, Metallurgie du Zinc (p. 163). The first patent granted for its use was that of Dony (French, Dec. 7, 1809), which called for a mixture of salt, chalk and potassium carbonate in the proportions of 1.4 per cent of the weight of ore NaCl, 4.1 per cent $CaCO_3$ and 0.2 per cent K_2CO_3. Later practice has reduced the proportion of salt to 1 per cent or less.

Volatilization of sodium chloride is evident from the first of the operation nearly to the end, and can be easily detected by the yellow flame. If the furnace is equipped with prolongs, a small amount of zinc chloride can frequently be found condensed in them, or if an excess of salt is added it is sometimes found in a layer of zinc chloride over the spelter.

Various hypotheses have been offered to explain the action of sodium chloride. These assume either a physical effect due to the entrainment of zinc vapor with the vapor of sodium chloride or a solution by the zinc chloride of any oxide coating formed on the condensed zinc particles. Although these may be contributing factors, the observations of Kiessling (*Berg. u. Hutt. Ztg.*, 1903, p. 613) have shown that sodium carbonate acts similarly to the chloride, though perhaps not quite so effectively. Since sodium carbonate is non-volatile and no zinc chloride can be formed, we must look for other explanations. A hypothesis is offered here which, though not free from objections, offers a basis for rational development.

The formation of blue powder is due to a reoxidation of the zinc by the carbon dioxide existing in the condenser according to the reversible reaction $ZnO + CO \leftrightharpoons Zn + CO_2$. Researches by the American Zinc, Lead & Smelting Co. show quite conclusively that the percentage of carbon dioxide in equilibrium with a given mixture is greater at high than at low temperatures.

The presence of salt may be supposed to modify the reaction between ZnO and carbon thus:

$$2NaCl + ZnO + C \leftrightharpoons 2Na + ZnCl_2 + CO$$

The amount of sodium chloride which reacts in this way is only a small percentage of the whole, the principal portion volatilizing as such. If the amount of zinc chloride formed is not large, it escapes from the condenser unnoticed, since the blue zinc flame is masked by the yellow of sodium. It also collects to some extent in the blue powder that is formed. The metallic sodium, being volatile, passes off with the zinc, and is the effective agent in reducing blue-powder formation, it does this by reducing the CO_2 content as the temperature falls, so that the sodium instead of the zinc is oxidized. Considering the two reactions,

$$2Na + CO_2 \leftrightharpoons Na_2O + CO$$

$$\frac{C^2_{Na} \times C_{CO_2}}{C_{CO}} = K'$$

$$Zn + CO_2 \leftrightharpoons ZnO + CO$$

$$\frac{C_{Zn} \times C_{CO_2}}{C_{CO}} = K''$$

K' is smaller than K'', and hence the sodium is oxidized and the zinc protected. Sodium carbonate would obviously effect the same result since the reaction

$$Na_2CO_3 + 2C \longrightarrow 2Na + 3CO$$

is known to proceed at fairly high temperatures. It has the advantage of being non-volatile and producing no zinc chloride, hence causing no zinc loss from this source. Sodium carbonate, however, tends to form slag, hence is objectionable. It should be noted that spelter made with the use of sodium chloride usually contains traces of metallic sodium, which can readily be detected by the flame test.

Thus a substance to be effective in reducing blue-powder formation must contain a volatile element more easily oxidized than zinc.

Anaconda, Mont.

Fusibility of Ash From Pennsylvania Coals*

By W. A. Selvig and A. C. Fieldner

PREVIOUS papers[1] gave a description of the standard gas-furnace method used by the Bureau of Mines in making ash-fusibility tests, a discussion of the relation of fusibility tests to clinker formation and tables giving a summary of results obtained for the coals of West Virginia and the Interior Province. This paper includes a table giving a summary of such tests on the coals of Pennsylvania, which State is by far the greatest coal-producing state in the Union.

Interpretation of Fusibility Table

The various coal beds of the bituminous coal field of Pennsylvania are arranged according to their geological succession, the uppermost beds being listed first. The samples are practically all standard mine samples collected according to the methods used by the Bureau of Mines.[2] A few car samples which were considered representative of the output of the various mines were also included.

The various coal districts of the anthracite region are arranged alphabetically under the field to which they belong. The samples are practically all delivery samples of the various sizes as marketed, only a few standard mine samples are represented.

FUSIBILITY OF COAL ASH FROM PENNSYLVANIA COALS

Series, Bed	Number of Mines Sampled	Total Number of Samples	Average Softening Temperature, Degrees F.	Ash in Dry Coal, Average Per Cent	Sulphur in Dry Coal, Average Per Cent
BITUMINOUS REGION					
MONONGAHELA SERIES					
Pittsburgh Bed	10	34	2360	7.17	1.43
CONEMAUGH SERIES					
Little Pittsburgh Bed	1	2	2390	8.13	1.70
ALLEGHENY SERIES					
Upper Freeport (E or Lemon) Bed	33	85	2350	9.35	2.13
Lower Freeport (D or Moshannon) Bed	21	70	+2390	8.52	2.06
Upper Kittanning (C Prime) Bed	7	18	+2350	8.67	2.16
Middle Kittanning (C) Bed	5	7	+2380	11.06	2.98
Lower Kittanning (Miller or B) Bed	39	162	+2550	7.86	2.03
Fulton Bed	4	12	+2940	7.36	1.18
Brookville (A) Bed	3	3	+2800	12.98	1.86
POTTSVILLE SERIES					
Bloss Bed	3	3	2630	11.96	2.25
ANTHRACITE REGION					
Northern Field					
Pittston District	1	1	+3010	6.03	0.58
Plymouth District	2	7	+3010	12.52	0.84
Scranton District	6	7	+3010	12.39	0.79
Wilkes-Barre District	3	4	+3010	13.17	0.78
Eastern-Middle Field					
Hazelton District	1	1	2960	14.50	0.61
Western-Middle Field					
Shamokin District	2	2	+2960	16.59	0.90
West Mahony District	3	3	+3010	.....	....
Southern Field					
East Schuylkill District	2	2	2990	11.19	0.78
West Schuylkill District	1	1	2730	18.07	0.82

NOTE.—A plus sign (+) placed before a given value denotes that the true value is above that indicated.

Values and Softening Temperatures

The number of mines sampled, number of samples represented, average softening temperature in degrees F., per cent ash and per cent sulphur on the dry coal basis are given for each bed tested in the bituminous coal field, and for each district in the anthracite region. Average values for each mine were computed from the individual samples, and from these values averages representing each bed or district were obtained. In some instances the average values given for the beds or districts represent only a few mines and are in such cases not truly representative. The point taken as the softening temperature is that at which the ash when molded into solid triangular pyrimids $\frac{3}{4}$-in. high and $\frac{1}{4}$-in. wide at the side of the base and mounted in a vertical position has fused down to a spherical lump. Samples remaining unfused at 3010 deg. F., which was the highest temperature attained in the test, were marked plus 3010 (+3010) and used as such in figuring the average values for the mine from which the average values of the beds or districts were computed.

Discussion of Fusibility Values

As stated in a previous paper[1] on the fusibility of coal ash from the Interior Province coals, the softening temperature of coal ash from the various fields of the United States ranges in general from 1900 to 3100 deg. F. This range of softening temperature for convenience in discussion is subdivided into the three following groups:

Class 1, refractory ashes, softening above 2600 deg. F.

Class 2, ashes of medium fusibility, softening between 2200 and 2600 deg. F.

Class 3, easily fusible ashes, softening below 2200 deg. F.

The softening temperature of the ash from the bituminous coal field of Pennsylvania are found in Class 1 and Class 2, principally in the latter. The beds of the Monongahela, Conemaugh and Allegheny series, with the exception of the Lower Kittanning, Fulton and Brookville beds of the Allegheny series, are very uniform as regards to fusibility and come in Class 2. The Lower Kittanning bed of the Allegheny series contains a large number of mines which give ash of high fusibility, and the average for this bed almost places it in the lower part of Class 1. The Fulton and Brookville beds of the Allegheny series, as also the Bloss bed of the Pottsville series, come in Class 1.

Older Beds Show High Softening Temperatures

It is interesting to note that the coals that show high softening temperatures are geologically the lower and older beds of the bituminous coal field. This was also found to be true of the coal beds of West Virginia. It has been found that in general the beds of the Monongahela and Allegheny series of Pennsylvania give a more refractory ash than do the same beds as found in West Virginia.

The ash from the anthracite region of Pennsylvania is very refractory, coming in Class 1. The softening temperature in practically every instance is above 3000 deg. F.

Fuels Chemical Laboratory,
Pittsburgh Experiment Station,
Bureau of Mines.

*Published by permission of the Director, United States Bureau of Mines.

[1]Selvig, W. A.; "Fusibility of Coal Ash From West Virginia Coals," CHEMICAL & METALLURGICAL ENGINEERING, Vol. 19, No. 12, 1918, pp. 826-828.

Selvig, W. A., Ratliff, W. C., and Fieldner, A. C.: "Fusibility of Coal Ash From the Interior Province Coals as Compared With West Virginia Coals," CHEMICAL & METALLURGICAL ENGINEERING, Vol. 20, No. 6, 1919, pp. 274-276.

For complete tables giving results obtained for each mine tested see: Selvig, W. A.: "Fusibility of Coal Ash From West Virginia Coals," *Coal Age*, Vol. 15, No. 1, 1919, pp. 12-16. Selvig, W. A. Ratliff, W. C., and Fieldner, A. C.: "Fusibility of Ash From Coals Found in the Interior Province," *Coal Age*, Vol. 15, No. 16, 1919, pp. 698-703.

[2]Holmes, J. A.: "The Sampling of Coal in the Mine," Technical Paper 1, Bureau of Mines, 1911, 18 pp.

Commercial Feasibility of Electric Smelting of Iron Ores in British Columbia*

Markets for Iron and Steel—Available Ore, Concentration of Low-Grade Magnetites—Cost of Electric Current Compared With Coke and Charcoal Reduction — Electrodes, Types of Furnaces—Cost of Plant and Smelting

A BRIEF abstract of Dr. Stansfield's main conclusions from his recent studies in British Columbia has already appeared in the columns of this journal (CHEMICAL & METALLURGICAL ENGINEERING, Vol. 20, p. 206, March 1, 1919). Appendices to his report constitute the bulk of its volume, containing material of large value to students of electric smelting, as well as shedding light upon the Western market for electric iron and steel.

MARKETS FOR IRON AND STEEL

Considerable divergence in opinion is recorded as to the British Columbian market for foundry pig iron—the most sizable outlet for simple furnace products. This is partially due to the fact that recent shortages and high prices have caused a considerable curtailment in custom founding, while recent shipbuilding is responsible for a large specialized output. During the year ended March 31, 1915, but 2341 tons of pig iron entered the ports of British Columbia and Alberta. Some probably was shipped from Eastern Canadian works, while considerable quantities of scrap are normally used in cupola work. This unquestionably augmented the supply, for 2341 tons of pig would be consumed in one sizable foundry in a month. Various men connected with the metal trades estimated that from 10,000 to 15,000 tons of foundry iron could be absorbed annually in British Columbia (apart from the shipbuilding industry) if the price could be made from $30 to $40 per ton, instead of the $60 to $70 ruling during the summer of 1918.

"Before the war, with Eastern prices about $15 per long ton, the price in British Columbia would be between $25 and $30. While it is impossible to predict the course of prices after the war, it seems likely, in view of the high cost of living and the increasing powers of the working-classes, that the price of labor, and consequently the price of manufactured products, will not return again in the near future to the pre-war figures. If we may assume that Eastern prices of pig iron will not fall below $20, it will follow that the normal price of pig iron in British Columbia will not fall below $35, or at the lowest price $30, for a period of several years.

"With regard to the possibility that a blast-furnace plant may be established in the State of Washington, and that it may capture the market for iron in British Columbia, I may state that the B. L. Thane Co. estimates the cost, under 1918 conditions, of making iron in the State of Washington at $22, $26 and $30, on three assumptions with regard to the cost of supplies. Taking the middle estimate, $26, and adding the freight, say $2, and the Canadian duty of $4.75, would raise the cost of iron delivered in British Columbia to about $33; a figure which is about the same as the cost of making electric-furnace iron with power at $15. The bounty offered by the British Columbia government would, apparently, turn the scale in the favor of the electric product. After the war the war duty of 7½ per cent *ad valorem* will no doubt be withdrawn, and in general we must expect that a blast-furnace plant on the Pacific coast would be able to take a part at least of the market in British Columbia for the cheaper grades of iron, but, with the help of the Canadian duty and the Provincial bounty, an electric smelting plant in British Columbia should be able to retain the local market for the higher grades of iron."

On account of the limited market for pig iron—which Dr. Stansfield estimates as 20 to 30 tons daily (at a price of $35), the recommendation is for a small electric plant which can produce steel and ferros as well.

AVAILABLE ORE

The report goes into the available ore supply in considerable detail. With no iron furnaces operating in the western region, it is only natural that none of these deposits are developed. However, some large ore bodies near tidewater have been prospected with sufficient thoroughness to warrant the opinion of competent geologists and mining engineers that several million tons of 55 per cent magnetite, low in phosphorus and sulphur, can be easily delivered at tidewater furnaces at a cost of approximately $4 per ton.

CONCENTRATION OF LOW-GRADE MAGNETITES

It is pointed out that it will oftentimes be cheaper to eliminate gangue mechanically than to slag it, especially by expensive electrical heat in a small furnace. As an instance, it is assumed that "the ore can be mined to contain 40 per cent of iron at a cost of $1 per ton, where the 50 per cent ore cost $2 to mine. Adding the fixed charge of 10c. and the royalty of 40c. (50c. for a 50 per cent ore), the crude ore will cost $1.50 per ton. The crushing to 80 mesh and magnetic concentration may cost 80c. per ton, making a total of $2.30. Suppose that 2 tons of ore yield 1 ton of a 70 per cent concentrate, then the cost will be $4.60 per ton of concentrate. To this we must add a charge of, say, $1 for sintering and $1 for freight, making a total of $6.60 per ton. This corresponds to $9.45 per ton of pig iron, which is $1.45 more than the cost using raw 50 per cent ore at $4 a ton. The saving in the smelting process, due to the use of a richer ore, would be in the order of $3 a ton of iron, thus making a saving of about $1.55 per ton."

On the other hand, Dr. Stansfield thinks it would not be advisable to dress a 50 per cent ore up to 65 per cent, if it involved sintering the concentrate. As a matter of fact about 25 per cent of fine concentrated ore (so-called "slig") is used in Swedish practice, while it

*Excerpts from Bulletin No. 2, 1919, British Columbia Department of Mines, by Alfred Stansfield, D.Sc., Professor of Metallurgy, McGill University.

would be the exact material required for a metallizing operation.

"The possibility of the commercial operation of an electric-smelting plant for the production of pig iron from iron ore depends on an adequate supply of electric power at a moderate rate. A large amount of power is needed, the amount varying somewhat with the richness of the ore, the grade of iron to be produced, and the kind of furnace employed. Under usual conditions the consumption of electrical power for each long ton of pig iron lies between one-third and one-half of a horsepower-year. For the production of foundry iron from rather low-grade ores, and in a simple pit furnace, it will not be safe to count on the production of more than 2 long tons of iron per annum for each eleectric horsepower supplied to the works. For a production of 50 tons of pig iron daily some 8000 or 9000 electric horsepower will be needed, and if provision is made for the production of ferro-alloys and the making of steel in electric furnaces, some 10,000 to 15,000 hp. must be provided.

Cost of Electric Power for Smelting

"The power companies in Vancouver were unable, during my visit, to give me definite information on this point, but I understood that power could probably be provided at about $15 per electrical horsepower-year; a price at which it seemed possible that electric smelting could be undertaken commercially. When my report was nearing completion, I received a letter informing me that the charges for electric power would be nearly twice the figure I had assumed in my calculations. Under this changed condition the electric smelting of iron ores by existing methods is scarcely possible, and the only remaining opening, unless cheaper power can be obtained, is by developing a new process."

So much for the commercial current already available. It appears that there is ample undeveloped power going to waste, and Dr. Stansfield was furnished estimates showing that 340,000 hp. at three accessible points could be developed for smelting purposes at about $10 per horsepower-year.

Such costs would be lower than for ordinary users, since the load factor would easily approach 90 per cent. "The power factor of these furnaces has been found to be very high in Sweden, where the supply is one of 25 cycles, but in California, using a 60-cycle supply, the power factor of the [open pit] furnace has been found to vary from nearly unity when the furnace is empty to as low as 65 per cent when the furnace is ready for tapping. I should think, however, that if special attention were paid to this side of the design of furnace, it could be made to keep the power factor above 80 per cent at all times. Voltage regulation is effected by a series of taps on the primary of the service transformers, there being usually three such transformers for each furnace, which are independently regulated. On account of this the transformers are of special design, and the primary voltage would not be more than about 10,000, and preferably in the order of 2000.

"It will be understood that such development [of new power houses] would be out of the question at the present time in view of the high cost of labor and supplies, and the difficulty of obtaining apparatus.[1] It seems probable, however, that within a few years after the termination of the war, wages and costs in general will arrive at some more settled condition."

[1]The report was dated Nov. 11, 1918.

Up to ½ ton of charcoal or coke is needed for the reduction of a ton of pig iron, charcoal being preferred for its greater purity, its higher electrical resistance preventing short circuiting at the top of the charge, and its friability producing intimate contact between ore and reagent.

"Theoretically, 1 ton of foundry pig iron will need 0.269 ton of carbon for its reduction from magnetite and about 0.035 ton for its carburization, assuming it to contain 3.5 per cent of carbon. It will also need 0.026 ton of carbon for the reduction of 3 per cent of silicon. The combined carbon requirement will thus be 0.33 ton per ton of pig iron. On account of the well-known purity of wood charcoal, it is often assumed that it contains at least 90 per cent of carbon, and that some 0.38 ton of charcoal will be sufficient per ton of pig iron. Actually, however, charcoal contains from 70 to 75 per cent of fixed carbon; the average over a long period in Sweden being 73 per cent, the balance being volatile matter and moisture, and accordingly some 0.44 to 0.47 ton of charcoal must be provided. In view of the custom of weighing iron by the long ton and charcoal by the short ton, it appears that ½ net ton of charcoal will be required. There is, indeed, a small amount of reduction by carbon monoxide, even in the open furnace, but this will be balanced by the combustion of charcoal at the top of the furnace and the other mechanical losses. Assuming that 5 per cent of the carbon monoxide is utilized in the open furnace and 25 per cent in the Swedish furnace, we find that 0.4 net ton of charcoal should be enough in the latter type of furnace. Mr. Gronwall, in his estimate, quoted in my report on 'Electrothermic Smelting of Iron Ores in Sweden,' allows 0.370 metric ton of charcoal per metric ton of foundry iron, and this would be 0.414 net ton per long ton of pig iron. It will be seen, therefore, that my estimate is supported both by theoretical calculations and by the results of practice in Sweden.

Comparison of Coke and Charcoal

The comparative values of these as reducing materials depend in the first place on their fixed-carbon content. Thus, if charcoal contains 73 per cent of fixed carbon and coke 84 per cent, the coke would appear to be the more valuable. The remainder of the charcoal, however, is volatile matter and moisture, which is driven off harmlessly in the furnace, while the coke would contain some 13 per cent of ash, which has to be melted, and will usually necessitate the addition of a flux. The sulphur in the coke also will need fluxing, in addition to lowering the purity of the resulting pig iron. It follows, from these and other considerations, that charcoal is somewhat more valuable than coke as a reducing reagent. Referring to Mr. Gronwall's estimate in my Swedish report, the following figures show the relative consumption of fuel and of electric power for 1,000 kg. of pig iron, according as charcoal or coke is employed:

TABLE I. REDUCER AND ENERGY FOR SWEDISH FURNACE

	Using Charcoal of 73 Per Cent Carbon		Using Coke of 85 Per Cent Carbon	
	Kilos Fuel	Hp.-Year	Kilos Fuel	Hp.-Year
White pig iron	340	0.37	370	0.39
Gray pig iron	370	0.40	400	0.42

"At the present time no considerable quantity of charcoal is produced in British Columbia, and its price is now $30 a ton. However, large quantities of Douglas fir mill waste are available and suitable for carbonizing in charcoal-kilns, the yields in by-products being unimportant.

"The regular charcoal-kiln is a circular brick structure holding about 50 cords of wood. It is charged and discharged by hand, and the volatile by-products are partly saved by being drawn through condensers, the permanent gases being returned and burnt in the kiln. If a battery of these kilns were established at a large lumber-mill so that the waste wood could be delivered mechanically to the kilns, the production of a ton of charcoal might cost:

2½ cords of mill-waste at $1	$2.50
Labor and other expenses of operation after deducting the value of the by-products	2.50
Carriage of charcoal to smelter	1.00
Total	$6.00

"For the electric-smelting plant about 40 tons of charcoal would be needed daily. Each kiln would yield 20 tons, but as the process is slow, requiring about fifteen days, some thirty kilns would be required. If a charcoal industry were established in suitable relationship to the lumber industry, charcoal could be delivered to the smelter at a cost of about $6 or $8 per ton, corresponding to $3 or $4 per long ton of pig iron.

Electrodes

"The electrodes used in the Swedish furnaces at the time of my visit in 1914 were 24 in. in diameter and 4 or 5 ft. long. They were provided with threaded ends, so that fresh lengths could be added as the electrodes wore away. They were of amorphous carbon and cost about 4c. per lb. The consumption of electrodes, when making white pig iron from high-class ores, was about 10 to 15 lb. per ton of pig iron, thus costing about 50c. per ton of product. In melting lower grade ores for foundry iron the consumption might be from 15 to 20 lb.; at present prices in British Columbia this would mean about $1.50 per ton of pig. A furnace of 3000 kw. uses six of these 24-in. electrodes.

TABLE II. BECKMAN AND LINDEN'S ESTIMATE OF COST

300-Ton-per-Month Electrode Plant

Baking kilns complete, including all burning apparatus	$20,000
Hydraulic press (500 tons per month, 600-ton pressure)	6,000
Two mixers	6,000
Molds	5,000
Calciner complete	40,000
Building complete	25,000
Crane	8,000
Conveying equipment and elevators	2,500
Crushing and screening apparatus	3,000
Kiln-sand	1,000
Tools, chain, etc	1,000
Contingencies, 10 per cent	11,850
Engineering	15,000
Total	$144,350

Cost of Making 2000 Pounds of Electrodes

Anthracite coal, calcined, crushed and sized	$20.00
Pitch at $20 per ton	5.00
Baking fuel, pound per pound ratio	4.50
Labor, 50c. per hour	12.75
Operating superintendence	1.85
Supplies	1.00
Maintenance	2.00
Plant office expense	.75
Main office expense	4.00
Total	$51.85
Cost per lb., 2.6c.	

"At Bay Point, Cal., the 3,000-kw. open-pit furnace, smelting ferromanganese, uses three 24-in. carbon electrodes. The consumption is 100 lb. per ton of ferromanganese, and Beckman and Linden expect that in using this furnace for making pig iron the consumption would be 20 lb. per ton.

"Under ordinary conditions carbon electrodes cost 3c. or 4c. per lb. [see Table II], but at the present time the price in the East is about 8c., and on the Pacific coast nearly 10c. It is desirable to make electrodes locally, but this should not be undertaken until the smelting plant is in good running order."

"There is a fair supply of laborers at nearly $4 a day, and most skilled men are scarce at about $6 a day. The cost of labor per ton of iron depends very much on the size and output of the plant. Thus, in a fully equipped plant making 50 or 60 tons of pig iron, and steel and ferro-alloys as well, the cost of labor might be $4 or $5 per ton of iron, but if only one or two furnaces were operating the labor cost might be about $7 per ton of iron.

"At Hagfors three 3000-hp. furnaces are operated by fifty men, working 8 hours daily, at a wage of about 12c. per hour. At this rate, with bonuses and the higher rates of foremen, the cost would amount to about 80c. a ton of pig iron. In a plant of three 3000-kw. furnaces in British Columbia fifty men might be assumed to cost: Thirty at $4 and twenty at $6, or $240 a day. With an average output of 75 tons daily of foundry iron this would mean $3.20 per ton. A plant of this size would probably need a few additional men, say ten or twelve, which would increase the charge for labor to about $4 a ton.

TABLE III. DAILY LABOR FOR ONE 3,000-KW. PIT FURNACE

One furnace foreman at $8	$8.00
Twelve furnacemen at $5	60.00
One chief electrician at $6	6.00
Three sub-station operators at $5	15.00
Three mechanics at $6	18.00
Six mixing-men at $4	24.00
Six metal-handlers at $4	24.00
Two locomotive-crane men at $5	10.00
Total	$165.00

"With an output of 25 tons per day this would mean $6.60 per ton of iron."

Type of Furnace

1. *Electro-Metals Furnace Used in Sweden.* This furnace has been described repeatedly—for instance, in Dr. Stansfield's book, "The Electric Furnace," 1914 edition, pages 174-211—and is doubtless familiar to most readers. It consists of a furnace shaft, quite similar to an ordinary small iron blast-furnace stack, independently supported above a relatively shallow crucible of larger diameter, the latter covered with an annular arch through which project the electrodes. Furnace gases are ordinarily recirculated through tuyeres between the roof of the crucible and the descending charge, both to cool the roof and preheat the content of the shaft. Typical analyses of pig irons made in large tonnage in Sweden (Hagfors?) are:

	For Open-Hearth	For Lancashire Treatment	For Bessemer
Si	0.4 to 0.6	0.2 to 0.3	1.0 to 1.4
Mn	0.3 to 0.5	0.2 to 0.3	2.5 to 3.0
P	0.011 to 0.018	0.011 to 0.018	0.015 to 0.019
S	0.015	0.015 to 0.020	0.005

During the early operation of the plant there was a tendency for the sulphur to be unduly high, but this was remedied by making the slag more basic whenever the furnace was run for Lancashire pig.

Excellent bessemer has repeatedly been made. The early attempts were not good, but it was soon found that Si and Mn had to be increased. It had been assumed that the amount would be normal, but apparently the lower temperature of the electro-bessemer pig as compared with ordinary bessemer pig from blast-furnaces necessitates a higher content.

General experience points to the following results: It

is cheaper to make spiegel than gray pig, because: (1) More current can be put through the furnace; (2) the current consumption is lower (per ton of product); (3) thus the production is higher; (4) the electrode consumption is lower; (5) the repair costs are lower.

It may further be stated that rich charges give better economic results than poor ones. The quality of the pig, however, is not influenced by the percentage of iron content of the ore.

For some time past the gas from the furnaces has been used as fuel in the open-hearth furnaces, and it is estimated that the value of the gas is from 50c. to 75c. per ton of pig iron produced.

In large plants white pig can be made from 65 per cent ore with 0.31 hp.-yr. per ton, or gray pig with 0.37 hp.-yr. per ton. Smaller plants on account of a greater "diversity factor" would require perhaps 0.41 hp.-yr. per ton of gray iron, or 0.45 hp.-yr. if the ore ran not over 55 per cent iron.

The following furnaces of this style have been constructed:

SWEDEN

Trollhatten,	one 2250-kw. furnace; one 3000-kw. furnace.
Hagfors,	two 2250-kw. furnaces; three 4,000-kw. furnaces.
Domnarfvet,	one 7000-kw. furnace; four 3000-kw. furnaces, one 2000-kw. furnace.
Soderfors,	one 5000-kw. furnace.
Ljusne,	one 3000-kw. furnace.
Porjus,	two 3000-kw. furnaces.
Lulea,	three 3000-kw. furnaces.

NORWAY

Tyssedahl (Hardanger), two 2600-kw. furnaces.
Arendal, two 2000-kw. furnaces.

SWITZERLAND

Two furnaces.

JAPAN

Three furnaces.

ITALY

Aosta, six 3000-kw. furnaces.

2. *Helfenstein Furnace.* "The Helfenstein furnace was originally devised for the production of calcium carbide and ferrosilicon. [See R. Taussig, MET. & CHEM. ENG., X., 1912, page 686.] A 10,000-hp. furnace of this type for iron-smelting was started at Domnarfvet in May, 1913. A more recent account appeared in MET. & CHEM. ENG., May 1, 1917, page 509, from which I have taken the following particulars:

"When charcoal was used, the consumption of power, etc., was 2170 kw.-hr., 380 kg. charcoal (70 per cent carbon), and 5 kg. of electrodes per metric ton of pig iron. When coke was used, the consumption was 2600 to 2700 kw.-hr., 310 to 320 kg. of coke, and 4 kg. of electrodes. The consumption of 2170 kw.-hr. with charcoal corresponds to 0.392 hp.-yr. at 85 per cent load factor. This is probably for the production of white iron from high-grade ores, though at the time of my visit ores of 50 per cent iron were being smelted. It does not appear that the efficiency is any better than that of the Electro-Metals furnace, and it should be noticed that the use of coke causes the consumption of a far greater amount of electrical power.

"The idea of this furnace is to increase the output and efficiency by using a far larger amount of power in a furnace of a given size than was possible in the Electro-Metals furnace. The furnace gases were not used to reduce the ore in the furnace, but were employed for other purposes in the plant. It is unfortunate that we have no detailed account of the operation of this furnace, or of the reasons which caused it to be abandoned."

The furnace itself is essentially a tall open-pit furnace with openings in the side walls somewhat below the top through which the gaseous products of smelting are sucked into a bustle pipe, to be transported elsewhere for use.

3. *The Noble Furnace.* After considerable experimentation between the years 1907 and 1911, one 2000- and one 3000-kw. furnace similar in form were evolved by the Noble Electric Steel Co., at Heroult, Cal. The latter was substantially a covered rectangular shaft 28 ft. long, 10 ft. wide, lined with firebrick, charged through vertical chutes 18 ft. high, in which the cold ore descended without heating. Between charging chutes the furnace was arched over; through these arches were four 12-in. graphite electrodes.

"The best account of this furnace was written by John Crawford, the plant manager, in METALLURGICAL & CHEMICAL ENGINEERING, July, 1913, Vol. XI, p. 383. The furnace gases are not used for preheating or reducing the ore, but are led away and used under limekilns and charcoal-retorts. The electric current is supplied to the furnace at a voltage of from 40 to 80. He found that coke was less satisfactory than charcoal in this furnace, but that if the coke was crushed a mixture of 60 per cent coke and 40 per cent charcoal could be used with fair efficiency. The following is an analysis of a 200-ton lot shipped to a foundry for making steel castings:

	Per Cent
Silicon	2.880
Combined carbon	0.098
Graphite carbon	3.300
Sulphur	0.028
Phosphorus	0.031

"Mr. Crawford does not consider this type of furnace as efficient as the shaft type, but states that he has kept the power-consumption as low as 2200 kw.-hr. per ton of pig in a furnace of 300 kw. This would equal 0.40 hp.-yr. at 85 per cent load factor. He states, however, that the long and narrow type offers the possibility of building several furnace units on to each other, like copper blast-furnaces, and this would lessen the radiation and electrical losses and increase the efficiency. It would also enable part of the furnace to be repaired while the remainder was still in operation."

4. *The Open Pit Furnace.* This type has been developed for calcium carbide and ferro-alloys; while it has never been used in the manufacture of iron, Beckman and Linden believe it is suitable for this duty. These men built and operated the furnace at Bay Point, Cal., for the Pacific Electro-Metals Co., illustrated and briefly described in CHEMICAL & METALLURGICAL ENGINEERING, Aug. 1, 1918, Vol. 19, p. 115. This furnace is a rectangular steel furnace, 17 ft. long, 9 ft. wide, and 7 ft. high, lined with 4½ in. of firebrick, and with a 3-ft. bottom of carbon butts. Three 24-in. carbon electrodes operate through the open top, spaced 3 ft. 6 in. centers, the lower ends being submerged in the granular furnace burden, which is shoveled constantly into the open top, heaping full. Current at 70 to 100 volts is used.

"There can be no question that charcoal pig iron of any desired grade can be made in this kind of furnace, which is easily and cheaply built and repaired, and should be able to run for a long time without need of repair. By providing an ample supply of power the efficiency should be satisfactory, and may be expected to approach fairly closely to that of the Swedish furnace. The charcoal-consumption will certainly be higher, but, as a poorer quality charcoal can be used, this need not cause any additional expense. The power-consumption will probably be higher; but it is impossible to speak

positively on this point, because the loss in heat, due to the open top and the absence of a stack, may be largely balanced by the greater efficiency of a higher-powered furnace, and by the fact that stoppages for repairs will be fewer and less prolonged. The consumption of electrodes will probably be larger per ton of pig iron, because they are somewhat exposed to the air, and perhaps also on account of the greater current density used in these electrodes. It is difficult to avoid the conclusion that, in operating such a furnace for the commercial production of pig iron, the management would ultimately be obliged to close in the furnace-top, so as to remove the gases from the furnace room. The furnace, so closed in, would then resemble the Helfenstein or the Noble furnace.

"If, then, it is decided to smelt in an electric furnace other than the Swedish type, it would be practicable to start with a simple pit furnace as used for ferromanganese."

Cost of Plant

Electro-Metals of London estimated the 1918 cost of a 6-furnace plant in Canada as $540,000, or $9 per ton of yearly output. These figures are based on a similar installation for Ansaldo in Italy. A plant for pig iron of half that size Dr. Stansfield estimates to cost $350,000 to $400,000, including land, wharf, trackage, and rolling stock, and when making gray pig of rather lower grade ore (53 per cent) would reduce 9000 tons per annum per furnace. This figures to approximately $15 per ton of yearly output.

"In order to obtain an independent judgment in regard to the general arrangement and cost of an electric-smelting plant in British Columbia, I discussed the design with Mr. R. H. Stewart of Vancouver, and he contributed some general considerations in regard to the design and cost data for the general portions of the plant, exclusive of the electrical furnaces and appliances.

"The design was for a plant of 20,000 hp. (15,000 kw.) for the production of 100 tons of iron daily and 20 tons of ferro-alloys. The plant was designed to handle daily the following quantities:

	Tons
Iron ore	200
Charcoal	50
Limestone	20
Electrodes	2
Manganese ore	20
Quartz	10
Chrome ore	10
Scrap-steel	20

"Although the plant as a whole was based on a daily capacity of 100 tons of iron and 20 tons of ferro-alloys, the electrical and furnace equipment is only about half of this, corresponding to a consumption of 10,000 hp., or 7500 kw., and a production of 50 tons of pig iron and 5 tons of ferro-alloys, provision being made for extension at a later date.

"The furnace building would be 50 ft. wide, 30 ft. high and 150 ft. long. It would contain along one long side two 3000-kw. open furnaces for smelting iron ore and three 300-kw. open furnaces for ferro-alloys. On the other side of this wall would be the transformer building, 30 ft. wide and 30 ft. high. The supplies of ore for the furnaces would be delivered by an elevated track in front of the furnaces and level with the charging-platforms. The furnace gases would be removed by flues below the charging platform. The pig iron could be tapped into large ladles and cast in sand or in a casting-machine or poured direct into a bessemer converter for steel-making. The ores and other supplies coming by water would be unloaded into storage by a locomotive crane. The charcoal would need a large storage shed, perhaps 300 ft. long and 90 ft. wide, which would contain a month's supply, stored not more than 10 ft. deep.

"The order of operations would be as follows:—

(1.) Unloading from the dock directly into storage.
(2.) Removal from storage, using the same crane, to crushing and sampling plant.
(3.) Removal from crushing plant to the furnace charge-bins.
(4.) Delivering from charge-bins over weighing-hoppers to the charge-cars and thence to the side of the furnace.
(5.) Smelting for pig iron or ferro-alloy.
(6.) Molten pig iron received in ladle and handled by crane to casting-bed or casting-machine or to steel-making furnace.
(7.) The slag would be received in a ladle and removed by a locomotive.

"The following is based on Mr. Stewart's estimate for the cost of buildings and general plant. Items for the [open pit] furnaces and electrical equipment have been added from Beckman and Linden's estimate:

20,000-HP. PLANT WITH 7000 KW. OF ELECTRIC FURNACES AND EQUIPMENT

Mr. Stewart's items:	
Locomotive crane, buckets and grab-buckets	$19,000
Dock, say	10,000
Electric locomotive, cars and equipment for handling between the wharf and the crushing plant	10,000
Crushing and sampling, say	17,000
Charcoal storage for one month's supply	8,000
Tracks, etc., for the above-mentioned equipment	3,500
Lifting-magnet for steel scrap, etc	1,200
Storage of manganese ore	3,500
Storehouse for electrodes and other supplies, including a small crane	6,000
Six furnace charging-bins, including weighing-hoppers and mechanical feeders	9,000
Tracks, charge-cars, and locomotive, with supports for the overhead track	10,000
Furnace building, including crane runway	25,000
Transformer building	12,000
3- to 10-ton ladles	6,000
Flues and stacks	25,000
20-ton crane, 50-ft. span	18,000
Laboratory and equipment	6,000
Office	5,000
Machine-shop and blacksmith's shop	12,000
Wash-house and change-room	3,000
Slag-handling equipment	8,000
Items from Messrs. Beckman and Linden:	
Two 3000-kw. 3-phase furnaces, installed	30,000
Seven 1000-kw. single-phase transformers	45,500
Two sets low-tension buses for 3000-kw. furnaces	10,000
Two sets high-tension buses, etc., for 3000-kw. furnaces	12,000
Three 300-kw. single-phase furnaces, installed	10,000
Four 300-kw. transformers, installed	10,000
Three 50-kw. single-phase transformers	2,000
One 25-kw. motor-generator set for regulators	2,000
Three sets low-tension buses for 300-kw. furnaces	1,500
Land, say	6,000
Engineering and contingencies, 20 per cent on $129,000	25,800
Total	$372,000

"Modifying this estimate to represent a plant of 9000 kw. making pig iron only, we have:

9,000-KW. PLANT FOR PIG IRON

Mr. Stewart's items	$217,000
Three 3000-kw. furnaces	45,000
Eleven 1000-kw. transformers	71,000
Three sets low-tension buses	15,000
Three sets high-tension buses, etc	18,000
Three 100-kw. transformers	3,000
One 25-kw. motor-generator	2,000
Land	6,000
Engineering, etc., 20 per cent on $160,000	32,000
Total	$409,000

"These figures agree with the previous estimate of $400,000."

Cost of Making Pig Iron in Swedish Furnace

Table IV contains available and estimated costs by Swedish practice. Costs from Electro-Metals are for a large plant, and show what can be done under exceptionally favorable conditions. Mr. Leffler's figures appeared in *Iron Age*, Sept. 13, 1917, p. 605. The increased amount in Stansfield's estimate is due in about equal proportions to the increased charges for ore power and labor. Items in Dr. Stansfield's estimates are

explained in previous sections, and interest is taken on $400,000 for plant plus $100,000 working capital, while 10 per cent depreciation (somewhat moderate) is figured on the plant.

Conversion of White Iron Into Foundry Pig

"On account of the fact that the Swedish furnace is generally used for the production of a white pig iron containing not more than about 1 per cent of silicon, we have no exact data for the production of foundry iron of, say, 3 per cent of silicon in this furnace. We are satisfied, however, that there would be a decided increase on this account in the cost for power, charcoal, electrodes and maintenance, besides the general overhead, labor and interest charges. In view of this, it is worth while to consider what the cost would be of converting white iron into foundry iron by the addition of ferrosilicon. One ton of iron containing 1 per cent of silicon would need the addition of 0.04 ton of 50 per cent ferrosilicon to raise its silicon content to 3 per cent. This ferrosilicon would cost, made in the plant, about $85 per ton, or $3.50 for the amount needed.

"If the pig iron were received in a large ladle and the ferro were thrown in red hot, there should be enough heat to effect a perfect mixture; and as the iron is cast into pigs for sale, and then remelted in a cupola, any irregularity would be remedied before the final casting. The saving in the cost of smelting through producing white iron instead of foundry iron would about equal the cost of the ferrosilicon, and there would be the added advantage of making a single furnace product and turning as much of this as was needed into foundry iron.

Difference in Cost

"Mr. Gronwall, in his estimate in 1914, places the difference in cost between gray and white pig iron as:

0.03 ton of charcoal.
0.03 horsepower-year.
5 lb. of electrodes.
10 cents for repairs.
7 cents for petty charges.

"Under our conditions this would mean:

Charcoal at $8	$0.24
Power at $15	.45
Electrodes at 8 cents	.40
Repairs and petty charges	.21
Total	$1.30

"We must add, however, a proportion of the charges for labor, management, and fixed charges amounting to about 60c., thus bringing the whole up to $1.90. The additional expense may easily be as much as 0.05 ton of charcoal and 0.05 hp.-yr., and the increased cost would then be about $3 a ton (everything considered), or nearly as much as the cost of the ferrosilicon addition.

"The ferrosilicon used was found to cost $3.50, but, as it replaces an equal weight of pig iron costing $1, the net cost of the addition will only be $2.50 per ton of the resulting foundry iron.

"The foregoing discussion is not intended to prove that the addition of ferrosilicon to white iron is the best way of making foundry iron, but merely that the use of the Swedish furnace for foundry iron would be perfectly safe, because ferrosilicon could be added without much additional expense if it were found impracticable to make foundry iron directly."

Cost of Smelting in Pit Furnace

Dr. Stansfield conservatively assumes the following power and charcoal used per long ton of iron in a pit furnace:

	Hp.-Yr.	Net Ton Charcoal
White iron from 65 per cent concentrate	0.35	0.45
White iron from 50 per cent ore	0.43	0.45
Gray iron from 65 per cent concentrate	0.42	0.50
Gray iron from 50 per cent ore	0.50	0.50

On such a basis the cost of making one long ton of foundry pig in pit furnaces (10,000-kw. plant) is as shown in Table V.

TABLE V. COST OF IRON FROM PIT FURNACE

	From 55 per Cent Ore			From 65 per Cent Concentrate		
	Quantity	Price	Amount	Quantity	Price	Amount
Iron ore	2 tons	$4.00	$8.00	1.43 tons	$6.97	$10.30
Electrical power	0.5 hp.-yr.	15.00	7.50	0.42 hp.-yr.	15.00	6.30
Charcoal	0.5 ton	6.00	3.00	0.5 ton	6.00	3.00
Electrodes	20 lb.	.10	2.00	20 lb.	.10	2.00
Flux	.....	.....	?	.....	.....	.....
Labor	.....	.....	6.00	.....	.....	6.40
Supplies	.....	.....	1.00	.....	.....	1.00
Plant and general office expenses	.....	.....	3.00	.....	.....	5.00
Interest and depreciation	20% on $120,000		3.00	20% on $140,000		2.81
Total	.....		$33.50	Total	.....	$36.81

In all the above estimates it should be carefully noted that electric energy was assumed to cost $15 per hp.-yr., the understanding which the author held until shortly before his report was written, as already noted above in the section on "Cost of Electric Power for Smelting." Charges of ½c. per kw.-hr. quoted him later are so high as to render impossible any large-scale production of electric pig iron in the Swedish or open-pit furnace.

Comparison With Blast-Furnace Methods

"It may be of value to compare with my estimate of the cost of making pig iron in the Swedish furnace the following estimates by the B. L. Thane Co. of the cost

TABLE IV. COST WITH SWEDISH FURNACES

	European Plant by Electro-Metals		North Sweden by J. A. Leffler		British Columbian 1918 by A. Stansfield		British Columbian Minimum by A. Stansfield	
Capacity per annum	60,000 tons white iron		?		27,000 tons gray iron		27,000 tons gray iron	
Ore	1½ tons	$1.50	1.6 tons	$4.38	2 tons	$8.00	1.7 tons	$5.00
Flux	½ ton	.50	.....	.16	.....	.....	.....	.....
Charcoal	0.33 ton	2.00	0.4 ton	5.00	0.4 ton	3.20	0.4 ton	3.20
Electrodes	10 lb.	.50	.....	.44	15 lb.	1.20	15 lb.	.60
Electric current	0.31 hp.-yr.	2.50	0.365 hp.-yr.	3.46	0.45 hp.-yr.	6.75	0.45 hp.-yr.	4.50
Repairs and maintenance	.....	.50	.....	.88	.....	1.00	.....	1.00
Labor	.....	2.00	.....	1.56	.....	4.50	.....	4.50
Management	.....	1.00	.....	.54	.....	2.00	.....	2.00
Interest and depreciation	.....	1.00	.....	.86	6 and 10%	2.60	6 and 10%	2.60
Royalty	.....	.....	.....	.34	.....	.50	.....	.50
Rents	.....	.....	.....	1.38	.....	.....	.....	.....
Carriage to market	.....	.....	.....	1.16	.....	.....	.....	.....
Total cost	.....	$11.50	.....	$20.16	.....	$29.75	.....	$23.90

TABLE VI. COST OF FERRO-ALLOYS

	80% Ferromanganese 300-Kw. Furnace			Silicomanganese 60% Mn; 20% Si 3000-Kw. Furnace			65% Ferrochromium 300-Kw. Furnace			50% Ferrosilicon 3000-Kw. Furnace		
	Quantity	Rate	Amount	Quantity	Rate	Amount	Quantity	Rate	Amount	Quantity	Rate	Amount
Ore	2.7 T 40%	$25	$67.50	3200 lb.	$25/T	$40.00	3 T 40%	$36.00	$108.00	.....	.....	.....
Steel turnings	300 lb.	$10/T	1.30	440 lb.	$10/T	2.00	100 lb.	$11/T	.50	1500 lb.	$10/T	$7.50
Lime rock	1500 lb.	$3/T	2.25	.....	.....	.....	.....	.....	.....	.....	.....	.....
Silica rock	.....	.....	.....	380 lb.	$4/T	.80	.....	.....	.....	2400 lb.	$3.50/T	4.20
Coke and charcoal	1400 lb.	$8/T	5.60	1800 lb.	$8/T	7.20	1350 lb.	$8	5.40	1200 lb.	$8	4.80
Electrodes	150 lb.	7c.	10.50	100 lb.	7c.	7.00	100 lb.	7c.	7.00	60 lb.	7c.	4.20
Power	0.9 hp.-yr.	$15	13.50	0.8 hp.-yr.	$15	12.00	1.4 hp.-yr.	$15	21.00	1 hp.-yr.	$15	15.00
Labor	.....	.....	8.00	.....	.....	8.00	.....	.....	12.00	.....	.....	16.00
Maintenance	.....	.....	5.00	.....	.....	5.00	.....	.....	5.00	.....	.....	.....
Supplies	.....	.....	2.00	.....	.....	1.50	.....	.....	2.00	.....	.....	1.50
Plant expense	.....	.....	3.00	.....	.....	3.00	.....	.....	10.00	.....	.....	15.00
Office expense	.....	.....	6.00	.....	.....	6.00	.....	.....	6.00	.....	.....	
	.....	.....	$124.65	.....	.....	$92.50	.....	.....	$176.90	.....	.....	$68.20

of making pig iron in a large blast-furnace near Puget Sound at 1918 prices:

B. L. THANE COMPANY'S ESTIMATE OF THE COST PER LONG TON OF BLAST-FURNACE PIG IRON

Iron ore, 3,457 lb. at $4.40 per long ton	$6.81
Coke, 2,485 lb. at $9.60 per net ton	11.93
Limestone, 1,000 lb at $1.90 per long ton	.81
Labor	1.50
Materials	1.50
Capital charges	3.40
Total	$25.95

"There does not appear to be any cause, other than the different size of the furnaces, why electric-furnace iron should cost more than blast-furnace iron under the conditions we find on the Coast, and providing that power can be obtained at $15 or less.

Auxiliary Industries

"In view of the limited market for foundry pig iron in British Columbia, it will be essential to make other products, so as to increase the output of the plant. For this purpose an additional output of low-silicon pig iron can be made, and this can be melted with steel scrap for the production of steel. Ferro-alloys, such as ferro-silicon, ferromanganese and ferrochrome, can also be made in an electric-smelting plant. These auxiliary industries not only increase the general output of the plant, thus reducing, proportionately, the overhead charges, but are themselves likely to yield a higher profit than the production of pig iron."

Attached is Table VI giving the itemized cost of various ferros.

On the basis of power at 0.5c. per kw.-hr., 80 per cent ferromanganese would cost $136.15 per ton. In 1913 this alloy sold in the Eastern States at $50 per long ton. [On April 15, 1919, this journal quoted $130 to $150 per long ton.]

A small furnace making silicomanganese with 0.5c. per kw.-hr. power would cost about $110 per ton. [Silicomanganese is not in general use among American steel plants.]

On the basis of power at 0.5c. per kw.-hr., 65 per cent ferrochromium would cost $194.40 per ton. [Such ferro-chromium was quoted in this journal on April 15, 1919, at from $416 to $520 per short ton.]

On the basis of power at 0.5c. per kw.-hr., 50 per cent ferrosilicon would cost $81 per ton. In 1913 this alloy sold at $73 per ton. In October, 1918, it is quoted at $160 per ton, and on April 15, 1919, it was from $90 to $150 per gross ton.

"In order to be able to make pig iron on as large a scale as possible, and also with a view to combining more profitable industries with that of iron-smelting, it is desirable to introduce into the electric-smelting plant furnaces and other appliances for making steel. The general scheme suggested is that about 25 tons of foundry iron should be produced daily for sale to iron-foundries, and a further 25 or 30 tons of white pig iron should be made for conversion into steel in the same plant or elsewhere. The steel would probably be made in small open-hearth furnaces heated by oil, or in electric furnaces of the Heroult type. Together with 30 tons of pig iron, about 60 tons of steel scrap could be used if desirable, thus yielding about 85 tons of steel daily. This could be used in part for making steel castings, and the remainder could be rolled into rods and bars of small section in a small rolling-mill. I may add the following estimate, made by Lyon & Keeney in 1915, for the cost of electric steel-making in the Western States (*Trans.*, Amer. Electrochem. Soc., 1915, XXVII., page 158):

COST OF PRODUCTION OF ONE LONG TON OF STEEL IN THE ELECTRIC FURNACE IN THE WESTERN STATES

1.1 tons of scrap at $15 per ton	$16.50
Slag materials	1.00
Ferro-alloys	1.00
800 kw.-hr. at 0.20c.	1.60
Labor	2.50
Maintenance and repairs	2.40
20 lb. of electrodes at 5c.	1.00
Amortization and depreciation at 5 per cent each	1.50
Interest at 6 per cent	.90
General	1.00
Royalty	.50
Total	$29.90

"The present cost of making steel in British Columbia will be considerably higher than this estimate, on account of the higher cost of supplies and operation."

Edgewood Arsenal Has New Commanding Officer

Edgewood Arsenal, which is the Gas Offensive Division of the Chemical Warfare Service, U. S. A., has now come under the command of Lieut.-Col. Amos A. Fries, Corps of Engineers, (C. W. S.), U. S. A., who as Brigadier-General, National Army, A. E. F., commanded the C. W. S. forces throughout the war in France.

Col. William H. Walker, formerly of the Massachusetts Institute of Technology, Boston, who has been the commanding officer of Edgewood Arsenal, has been honored with a Distinguished Service Medal by the Secretary of War and is now returning to pursue his profession in civil life.

Edgewood Arsenal, with its headquarters at 311 West Monument St., Baltimore, has arsenals located at Edgewood, Md.; Hastings-on-Hudson, N. Y.; Kingsport, Tenn.; Midland, Mich., and South Charleston, W. Va. The arsenals formerly located at Stamford, Conn.; Bound Brook, N. J.; Niagara Falls, N. Y., and Buffalo, N. Y., have been sold.

Decision on Frasch Patents on Sulphur Mining

By Hugo Mock and Asher Blum

THE Circuit Court of Appeals of the Third Circuit, which is a Federal Appellate Court having jurisdiction over the States of Pennsylvania, Delaware and New Jersey, rendered the following decision in March which, as the Court states, "involves basic matters affecting the whole sulphur product of the United States."

A proper comprehension of this extremely important decision, which enables the Freeport Texas Co. and other concerns owning sulphur beds similar to the enormous deposit found in Louisana to compete with the Union Sulphur Co., requires a brief historical survey of sulphur mining as originated and practiced in America.

Prior to the development of sulphur mining in America, nine-tenths of the world's supply was produced in Sicily by extremely primitive methods which involved shafting and other ordinary methods used in mining. In 1869 an enormous deposit of sulphur was discovered in Louisana when a well was being drilled for oil. All efforts to mine this proved unsuccessful for twenty-five years until Herman Frasch took up the problem.

Court Eulogizes Mr. Frasch

The Court pays a handsome tribute to Mr. Frasch, who, it states, "in inventive fertility and past experience seemed to be the one man to solve the difficulty and successfully work out one of the most remarkable wonders of world commerce."

Mr. Frasch resolved to give up the mining methods and shafting which had proved ineffectual because of the presence of quicksand and water and because of the presence of sulphurous gases which had killed several men. Mr. Frasch was very experienced in oil well work and his "daring, original and inventive step" consisted in forcing hot water into the sulphur bed so as to melt the sulphur, and then pumping up the molten sulphur to the surface and separating it from the water.

In 1890, Mr. Frasch filed applications in the United States Patent Office which resulted in the grant of U. S. Patent No. 461,429 for a process of mining sulphur, and Patent No. 461,430, which covered apparatus for mining sulphur, and these patents were issued on Oct. 20, 1891, so that by operation of law they would expire on Oct. 20, 1908, and then become free, public property. A third patent, No. 461,361, also issued on the same day, but it played no importance in the decision.

The First Frasch Patent

In the U. S. Patent No. 461,429 Mr. Frasch stated that his method was useful for sulphur deposits which were overlaid with beds of quicksand which therefore prevented shafting. The method disclosed in this patent required that an ordinary well should be drilled through the limestone above the sulphur, a casing being forced through this limestone and through the quicksand by the ordinary methods used in drilling oil wells and the like. This shut off water and the quicksand. When the casing reached the sulphur, a hole of smaller diameter was continued to the bottom of the sulphur deposit. Tubing of smaller diameter than the casing was then passed through the casing and the hole in the sulphur in a central position, and this tubing was passed above the ground to a casing head. Water at about 270 to 280 deg. Fahrenheit was then forced down by a pump between the tubing and the casing to the bottom of the hole in the sulphur, where it melted the sulphur and forced it up through the tubing to proper separators.

U. S. Patent No. 461,430 also showed a pump at the bottom of the tubing which could be used to raise the molten sulphur. Thus the mine could be filled with hot water to melt the sulphur and the sulphur could be periodically removed by this pump. A modification of this apparatus showed a bleed pipe extending from the surface of the ground to the hole in the mine, the bottom of the bleed being higher than the bottom of the casing and tubing. This bleed pipe could be used to draw off the hot water while the sulphur was pumped up by the pump before mentioned.

Frasch's first well was drilled in the fall of 1894 and was worked for four or five hours, producing about 500 bbl. of sulphur, when mechanical difficulties due to the sulphur corroding the iron-working parts of the valve and pump, and the weakness of the boiler used to supply the hot water, caused the stoppage of operations.

Why Complete Commercial Success Was Delayed

Various reasons delayed complete commercial success until 1903, but the Court stated, "We are satisfied that such delay and difficulties were not caused by defects in Frasch's original conception or in means to utilize it. As already pointed out, Frasch was immersed in other work; he regarded this as a side issue; his visits were infrequent; the work was frequently suspended, for as much as a year at a time; the finances were such that the work was badly hampered."

In the meantime, and before commercial success had been secured, Frasch filed another application, on May 27, 1897, which resulted in the issuance of two patents on Sept. 19, 1905, 799,642 and 800,127. In addition, Frasch was also granted U. S. Patent No. 1,008,319 on Nov. 14, 1911.

In U. S. Patent No. 799,642, Frasch stated that his earlier patents were unsatisfactory because since the sulphur had been found to be porous he could not develop sufficient pressure with the water pump to raise the column of molten sulphur and that a lifting pump gave trouble with its valves. In addition, the water with which the deposit of sulphur was saturated cooled the incoming hot water so that the yield of sulphur was small. The novelty in this patent consisted in not returning the water to the surface, but forcing it out through the porous rock so as to heat it even when the temperature of the water was below the melting point of sulphur. The water was now forced in at about 300 deg. Fahrenheit to counteract the effect of the cold water in the porous deposit.

Frasch's Later Patent

The apparatus shown in this patent showed a pipe corresponding to the casing of the earlier patents, which was driven down to the rock. An inner and centrally located hot water pipe was then passed through the casing to the bottom of the sulphur. This hot water pipe had a plug at its bottom and was perforated above the plug so as to allow the hot water to escape into the mine. A sulphur-raising pipe of less diameter than the hot water pipe was centrally located therein and was connected with the plug of the hot water pipe. The bottom of the sulphur-raising pipe was provided with a strainer and had an air-injecting pipe located

therein which was provided with a perforated bottom piece. Of course all these pipes extended to the surface of the ground. The bottom of the casing, or mine pipe as it is called, was higher than the bottom of the hot water pipe. Hot water was forced into the mine pipe and also into the hot water pipe, so as to fill them to a certain height. The hot water issuing from the mining pipe melted the sulphur and caused it collect around the bottom of the hot water pipe and the sulphur-raising and air-injecting pipes so as to seal them, while the water from the hot water pipe flowed directly over the molten sulphur and kept it hot. The hot water was allowed to flow away through the surrounding porous rock. Air was injected from the air pipe until the density of the sulphur was lowered to about that of water so that it could be easily raised by the column of water in the hot water pipe.

U. S. Patent No. 800,127 had about the same disclosure as No. 799,642, and mentioned that no provision was made for the return of the hot water which was forced out through the walls of the cavity in the sulphur and into the walls of the surrounding rock. U. S. Patent No. 1,008,319 covered the idea of injecting the hot water into the mine through a strainer so as to divide the stream of hot water over a wider zone and prevent clogging.

Union Sulphur Co's Claims

The Union Sulphur Co., which had acquired these three later patents, sued upon claims 2, 3, 6, 12, 19, 21 and 22 of No. 799,642, upon claims 2, 3, 7, 11, 21 and 24 of No. 800,127, and upon claims 7, 20 and 28 of No. 1,008,319.

The claims of No. 799,642 attempted to cover particularly the following points:

1. The forcing of water heated above the temperature at which melted sulphur begins to darken into the deposit and out through the surrounding rock, and removing the melted sulphur.

2. The use of injected air to lessen the density of the sulphur.

3. The injection of hot water into the cavity in the sulphur at two different levels, that is, one from the casing or mine pipe and another from the hot water pipe.

The claims of No. 800,127 in issue attempted to cover the apparatus for carrying out the above-mentioned process. The three claims of No. 1,008,319 attempted to cover the point already defined, namely, spraying out the hot water through a strainer.

Importance of the Litigation

The great importance of the litigation consisted in the fact that the porous character of the sulphur deposit made sulphur mining in America impractical unless the process and mechanism disclosed in the later patents and covered by these claims were used, so that if these claims would have been sustained the Union Sulphur Co. would have had a monopoly at least up to Sept. 19, 1922, when its patents No. 799,642 and No. 800,127 would expire.

The Union Sulphur Co. contended that when Frasch commenced his operations and applied for his patents issued in 1891 he was absolutely ignorant of the porous character of the Louisana sulphur deposit and that he believed that it was impervious to water, which was alleged to be the case in the Sicilian sulphur deposits, and that the earlier Frasch patents were valueless and impracticable, while the later Frasch patents involved an advance over them of great practical merit.

The Freeport Texas Co. contended that Frasch well knew from the very inception of his operations that the Louisiana deposit was porous and that the later Frasch patents represented nothing novel or patentable over his earlier patents, but were merely an attempt to stretch out the monopoly of the Union Sulphur Co. so that it would have the control of the American sulphur market from 1908 to 1922, and it pointed out that while Frasch had filed his second series of patents in 1897 the actual issuance of these patents had been delayed until 1905.

The Court's Decision

The Court very carefully analyzed all the testimony in a decision covering eighteen printed pages, and it came to the conclusion that since Frasch had examined a sample of the Louisana sulphur and from other circumstances he was well acquainted with the porous character of the Louisana deposit from the commencement of his work and that there was no basis for any patentable novelty in the later patents. The Court held that it involved no invention to apply the hot water at two different levels instead of at one, as was done in the first Frasch patents, or to use air pressure as a means of bringing the liquefied sulphur to the surface, and that Frasch's former patents were not restricted to a tight and non-porous rock. The Court also held that to distribute the hot water through a perforated lining was a common mechanical expedient and involved no invention. Accordingly, it ordered the complaint of the Union Sulphur Co. to be dismissed.

Does Not Bar Other Suits Elsewhere

This decision does not prevent the Union Sulphur Co. from bringing a like suit against some other company which may be located outside of the States of Pennsylvania, Delaware and New Jersey, and while the Federal Courts outside of the Third Circuit would feel inclined to follow the decision of this Circuit Court of Appeals, they are not bound to do so, and since a number of cases have arisen where the Circuit Courts of Appeals of different circuits have disagreed in their decisions upon the same patents, there is a possibility of the patents being sustained in some other of the nine judicial circuits into which the country is divided. The Supreme Court may still exercise its discretion to review the decision of the Circuit Court of Appeals of the Third Circuit and this will almost certainly follow as a matter of course if some other Circuit Court of Appeals disagrees with the Circuit Court of Appeals of the Third Circuit, as in such event the Supreme Court finally passes upon the case, so as to cause uniformity of authority throughout the entire country.

New York, N. Y.

Removal of Tin Import Restrictions

Applications for licenses to import tin ore and tin concentrates will be considered by the War Trade Board. These licenses will permit the importation of shipments made from points of origin on or after June 8, 1919, and will not be valid for entry until July 1.

Civil Service Examination.—Applications will be received until July 1 for the position of superintendent of heat treatment. There is a vacancy in the U. S. Naval Ordnance Plant, South Charleston, W. Va., at $5000 a year.

Kingsport, Tennessee, and Its Chemical Industries—II

A Brief Historical Survey of a Progressive Young American City, With a Technical Description of Its Varied Chemical Plants and Their Processes—Coal-Tar Dyestuffs and Intermediates—Tannery and Tanning Extract Plant—Wood Pulp

THE plant now owned and controlled by the Union Dye & Chemical Corporation was built by the Federal Dyestuff & Chemical Co. in 1915-16. Operations were begun in 1916, and after a brief career, the Federal Co. went into the hands of a receiver in 1918. On Aug. 15, the same year, the plant was sold by the receiver to the Union Dye & Chemical Corporation, Chester A. Jayne, president, J. F. White, general manager, and J. J. Bajda, technical director. The company is capitalized for $3,000,000 and has offices at 2 Rector St., New York, N. Y.

The new company is not only manufacturing the products of its predecessor, but is planning and preparing to greatly expand its scope, and to place on the market a line of chemicals, dyestuffs and intermediates far more extensive than the limited variety produced by the former owners of the plant. Buildings and equipment are being overhauled and remodeled, and new machinery is being installed, preparatory to instituting substantial economies in operating methods, and to producing the best grade of goods at lowest possible cost.

The principal colors now being manufactured are sulphur black, sulphur blue, sulphur red, sulphur brown, sulphur green, sulphur yellow and sulphur maroon. Other chemicals now being produced for sale are: Aniline and its derivatives, ortho- and para-toluidine, azo colors, intermediates, caustic soda, monochlorbenzol, bleaching powder, hydrochloric acid, nitric acid, and alizarine dyes.

It should be understood that on account of the keen competition in the dye industry, it is impossible to publish very many of the details of equipment or of processes in this plant. As some of these processes have been worked out after much painstaking and expensive research work, necessarily the nature of the materials used and of the chemical reactions involved in the dye-making processes cannot be fully disclosed.

All power used at this plant, as at all the industrial plants of Kingsport, is obtained from the Kingsport Utilities Corporation. No interruptions to this power are experienced, but in case for any reason this power should fail, the dye company could generate its own power. The company has two air compressors, and is now installing an ice plant, the manufactured ice and the cold circulating brine to be used in its chemical processes. The boiler house is equipped with two Henry Vogt Machine Co. boilers, 300 hp. each, and these furnish steam for heating and drying purposes.

Sulphur Black and Sulphur Blue

Sulphur black is made in the dinitrochlorbenzol nitrating building. Monochlorbenzol is treated with a mixture of nitric and sulphuric acids of high concentration in nitrators (of which three have been installed), heated with steam coils. The product of this treatment is dinitrochlorbenzol. This is blown into fusion kettles, and from there to oxidizing kettles, where it undergoes further treatment, and is then filter-pressed and dried by vacuum and steam. The product, known as crude sulphur black, is sent to the standardization department, and here it is analyzed and brought to standard strength. This dye, known as standard sulphur black, is then packed in strong wooden barrels, containing about 500 lb. each, for shipment. It is used for dyeing cotton or wool, but not for silk.

The process for the manufacture of sulphur blue is practically a duplication of the sulphur black process, with, of course, the necessary substitution of chemicals. The starting point for sulphur blue is indophenol. This is blown first into fusion kettles, then into oxidizing kettles, where it is oxidized, and is then filter-pressed. From the filters, the crude sulphur blue is sent to the drying room, where it is placed on trays, which are arranged on shelves in the hot air cupboard, and subjected to a blast of hot air, which passes over and under the shelves. The dried dye is then sent to the standardizing department, where it is standardized, and is then placed in ball mixers (revolving steel drums containing iron balls), where the dye is crushed to powder. Sulphur blue is used for dyeing cotton, wool and silk. The capacity for the manufacture of sulphur blue or black is practically unlimited, the output being determined by the demand.

Nitrobenzol and Nitrosophenol

Nitrobenzol is manufactured by the usual process of mixing benzol with a mixture of nitric and sulphuric acids of high concentration. The acid mixture consists of 29 per cent HNO_3, 61 per cent H_2SO_4, and 10 per cent water. The chemicals are heated in steam jacketed nitrators, each provided with an agitator, manufactured by the Buffalo Foundry & Machine Co. There are four of these nitrators, each 10 ft. high by 6.5 ft. in diameter. The reaction takes place at 140 to 150 deg. C. When the reaction is completed, the nitrobenzol is blown to the nitrobenzol wash-house. Here the nitrobenzol is washed four times in a wooden vat provided with an agitator. The washed nitrobenzol is then drawn off into a blow-case, and blown to the aniline plant, where it is received in twelve feed tanks, supplying twelve reducers. The latter are steel cylinders on end, 10 ft. high by 8 ft. in diameter, each heated by a steam coil and provided with an agitator. The nitrobenzol is fed into the reducer, along with iron borings screened to 40-mesh size. Heat is applied and the reaction starts immediately. The mixture is agitated continuously for from 24 to 36 hours. As the reaction proceeds, the temperature is gradually increased, and the aniline vapors pass off through a 6-in. pipe to condensers, which are steel cylinders, 25 ft. high by 6 ft. in diameter. Here the vapors are condensed, and the liquid is collected in receiving flasks.

Nitrosophenol is manufactured as follows: Phenol and caustic soda are mixed in one tank, and water,

UNION DYE AND CHEMICAL CORPORATION

sodium nitrite and sulphuric acid in another. The two liquid mixtures are then agitated together in a tank provided with a mechanical stirrer revolving at the rate of 38 r.p.m. The product, nitrosophenol, is filtered, then centrifuged. The time required for the manufacture is about six hours. Nitrosophenol must be handled in containers made of steel or other non-combustible material. Indophenol is made by combining nitrosophenol, sulphuric acid and orthotoluidine in condensation tanks equipped with agitators and brine coils. When the reaction is completed the indophenol is allowed to flow into tanks, where it is precipitated by means of sodium carbonate. After precipitation is completed, the indophenol (an intermediate used in the manufacture of sulphur blue) is filter-pressed. After filtering, the indophenol still carries about 50 per cent of moisture. It is placed in buggies and used in the sulphur blue department. The total time required for the manufacture of indophenol is eight hours.

Chlorine for making the monochlorbenzol used in the manufacture of sulphur black is made in the electrolytic cell house. A solution of common salt is electrolyzed in the Allen-Moore cell, manufactured by the Electron Chemical Co., 347 Madison Ave., New York City. There are three series of cells, 136 cells to a series, or 408 cells in all. Caustic soda is made here as a by-product. The caustic solution goes to evaporators, where it is concentrated to a strength of 30 per cent. The strong solution is then pumped to cooling tanks, cooled, and the salt settled out. The caustic solution then passes to storage tanks, and thence to the finishing department, where the caustic is brought to the solid state, and packed in drums for shipment.

In the still house, containing three stills, liquid residues from the various manufacturing operations go through a fractionating process for the recovery of benzol, monochlorbenzol and dichlorbenzol.

In the chlorination house benzol and chlorine come into contact with each other in counter current, in Lummus chlorination columns, of which there are six. The product, monochlorbenzol (used in the manufacture of sulphur black) is pumped to a washer and washed, and is then pumped to storage tanks for use as needed. The exit gas escaping from the top of the chlorination columns goes through a cooler, then to the hydrochloric acid house. The latter contains three towers, arranged in series, built of acid-proof stoneware furnished by the United States Stoneware Co. of Akron, Ohio, and packed with acid-proof brick and 6-in. spiral rings. The liquid flows from tower to tower in a direction opposite to that taken by the gas. The liquid is elevated to the tops of the towers by pulsometers made of chemical stoneware (likewise furnished by the United States Stoneware Co.), through 1-in. glass tubes. All of the hydrochloric acid manufactured is placed on the market.

Nitric Acid Department

In the nitric acid department there are four retorts now operating, and four more will soon be installed. The retorts, manufactured by the Pratt Engineering Company of Atlanta, Ga., take a charge of 7000 lb. of nitrate of soda each. Sulphuric acid 66 deg. B., recovered from the spent acids used in other manufacturing processes, is added to the retorts, and the mixture distilled. The fumes are condensed in S-shaped Duriron pipes sprayed with water, and the gases uncondensed there go through a series of five chemical stoneware towers, the five towers serving as a common condensing system for the four retorts. The last tower of the series is fed with water, and the liquid then goes from tower to tower in a direction opposite to that taken by the gas. As in the hydrochloric acid plant, the liquid is pumped to the tops of the towers by means of chemical stoneware pulsometers through 1-in. glass tubes.

The nitric acid condensed in the S-condensers, after passing through Duriron bleachers, is received in Duriron flasks. Two grades of nitric acid are made—a strong acid, made in the condensers, and a weak one, made in the towers. The strong grade is used in the sulphur black process, where only 4 per cent of water is allowable in the acid mixture; while the weaker grade is used for the manufacture of nitrobenzol, where the water in the acid mixture may be as high as 10 per cent.

To make the mixed acid used in the dye-making processes, the nitric acid is pumped into a steel mixer equipped with an agitator, and is there mixed with oleum, which is purchased from the General Chemical Co., of Pulaski, Va.

The spent acid recovery plant is for the recovery of sulphuric acid from the spent acids used in other manu-

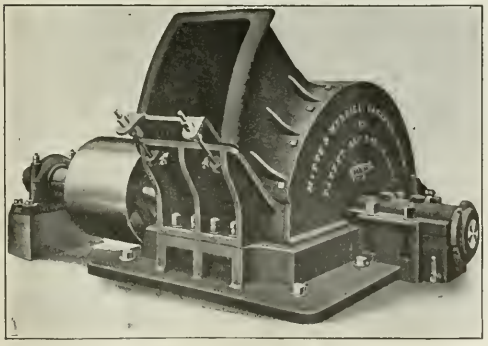
facturing processes. The spent acid is fed into a tower made of acid-proof brick, and packed with chemical brick and 6-in. spiral rings, up which pass the combustion gases from the furnaces used to heat two benches of pan concentrators. The acid discharged from the tower divides, and goes to both of these two benches, each of which consists of three cast-iron pans arranged in cascade and in series. The 66 deg. acid flows from the lowest pan of each series into a cooler, and this is sent to the nitric acid department to be used in the manufacture of nitric acid.

Tannery and Tanning Extract Plant

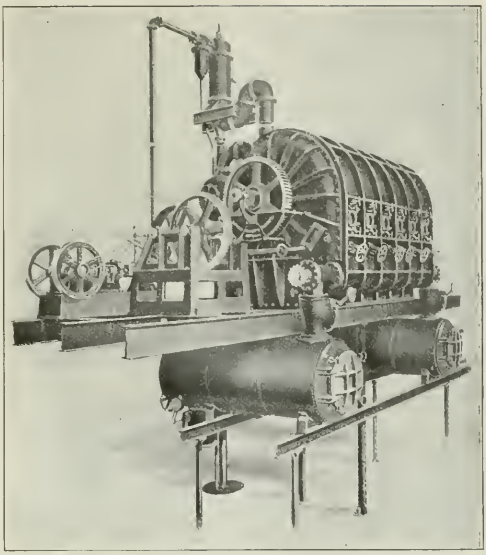
The latest industrial development of Kingsport is the Lang-Grant Leather Corporation, recently organized by the Simmons Hardware Co. of St. Louis, Mo. On the first day of April, this year, this recently organized company took over the control of the plants of the Kingsport Extract Corporation and of the Kingsport Tannery, Inc., both recently purchased for the purpose of consolidation with a new plant, already under construction, for the manufacture of finished leather goods, such as harness, saddles, horse collars and gloves. The existing plants will be described briefly first, and then the plans of the new organization for the future will be discussed.

The Kingsport Extract Corporation manufactures tanning extract from chestnut wood, oak bark and hemlock bark, all of which abound in the vicinity. From these raw materials, three different kinds of extract are made, chestnut, oak and hemlock. The first step in the manufacture of tanning extract is to shred, or chip, the wood, and grind the bark. The bark is put through a bark mill, and the ground bark is then delivered to the leaching vats. The chestnut wood is put through a chipper, commonly called by the extract men a "hog," manufactured by Mitts & Merrill, Saginaw, Mich. From the chipper the wood goes to a shredder, made by the Jeffrey Manufacturing Co., Columbus, Ohio. The wood, as discharged from the Jeffrey shredder, is not in the most desirable condition for conversion into paper pulp, and since the erection of the neighboring pulp mill, which now utilizes a large proportion of the spent chestnut chips of the extract company, the wood destined to reach the pulp mill is chipped by passing it through a Carthage disc chipper, made by the Carthage Machine Co., Carthage, N. Y.

In whatever way the wood may be comminuted, the chips are delivered to the vats and treated with water



WOOD CHIPPER



VACUUM DRUM DRIER

and steam. There are three sets of vats, eight vats to a set, each vat 14 ft. in diameter by 15 ft. high. Of the eight vats in a set, one will be loading chips, one discharging spent chips, and six in service. The solution is pumped in series from one vat to the next in the set, a fresh supply of water being introduced in the vat containing the chips which are most nearly spent, and the strongest liquor going to the vat containing a new batch of chips. Thus, as the liquor proceeds from vat to vat, it comes in contact with chips containing more and more undissolved tannin, and so the solution becomes stronger and stronger. Steam is introduced into one vat only—the first, containing the fresh supply of water and the nearly spent chips.

After coming in contact with a new batch of chips, the strong solution is withdrawn, and is then evaporated under 14 in. vacuum in copper evaporating pans heated by copper steam coils manufactured by Jos. Oat & Sons, Philadelphia, Pa. The evaporation here is carried to 65 deg. as indicated by the barkometer. There are four of these evaporators, three large and one small.

The concentrated solution obtained from these evaporators is further evaporated to a powder in the vacuum drum drier, manufactured by the Buffalo Foundry & Machine Co.

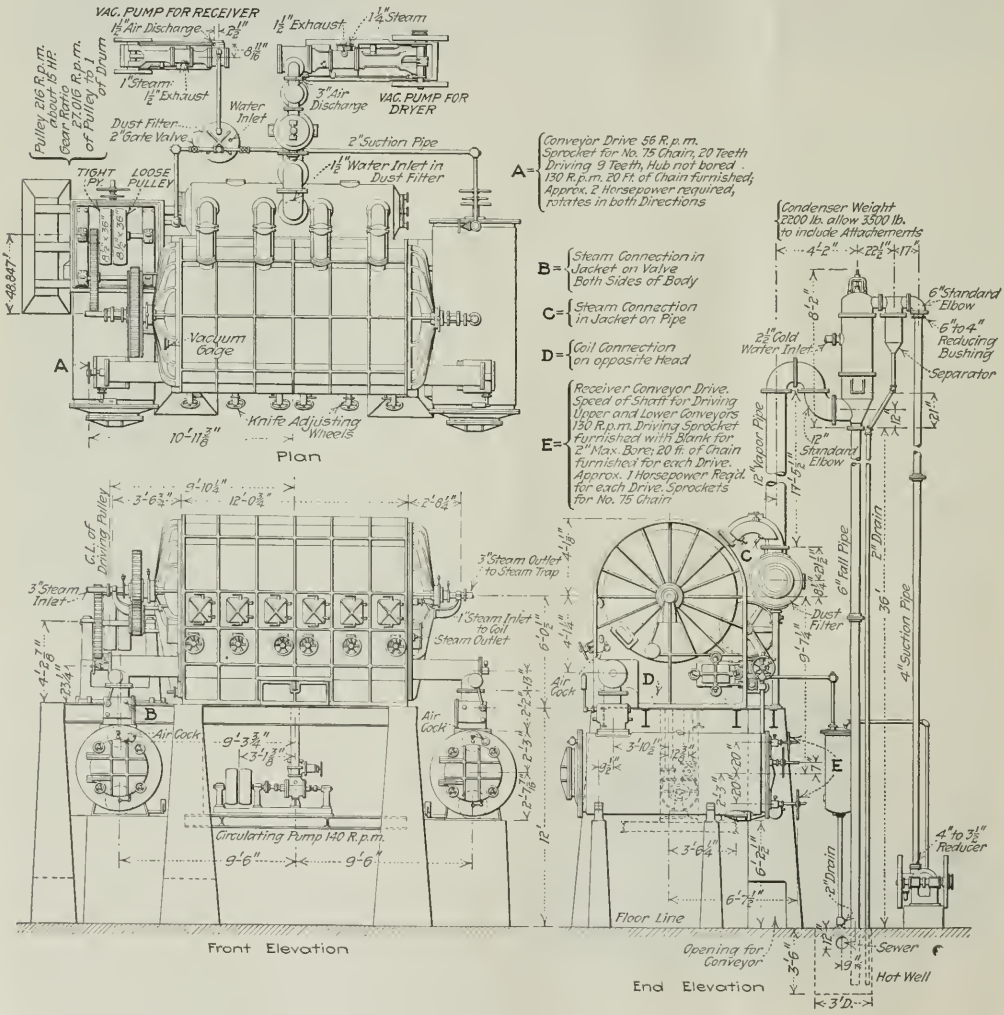
The high content of wood sap sugars in the concentrated extract makes drying without caramelizing impossible in bulk boiling processes. After the extract has been evaporated in bulk to a point where solids are tending to form on the heating walls of the concentrator, the liquor is pumped to the vacuum drum drier reservoir. From here it is circulated through the drum coating pan in such a way that all foam is removed and a homogeneous layer of extract syrup applied to the rotating steam heated drum. The speed of the drum is so adjusted that a layer of dried extract is obtained at the scrapers and dropped into the conveyor. Twenty-eight inches of vacuum gives the necessary low boiling temperature and there is no possibility of burning or oxi-

dizing the extract. The flaked extract goes by a conveyor belt from the drum drier to the shipping room, where it is packed in bags. It will be appreciated that a very important saving is made in shipping costs as compared with the old barreled liquor method. The capacity of the extract plant is 45,000 lb. per day.

Kingsport Tannery, Inc.

A natural adjunct to a tanning extract plant is a tannery, and the Kingsport Tannery, Inc., has for some time been operated under the same management as the Kingsport Extract Corporation. Every tannery uses its own blend of tanning extracts. The blend adopted by the Kingsport Tannery consists of 80 per cent chestnut and 20 per cent oak.

The raw hides as received from the slaughter houses are folded and tied up in bundles about 16 in. square. They are unfolded, and soaked in water for two days to eliminate dirt and blood. They are then placed in vats, where they are treated with a solution of lime for five days, during that time being reeled over from one vat to another, getting a little stronger solution of lime each day. They are then put into warm water, and depilated. After that the hides are "fleshed," i.e. all adhering bits of flesh are cut away by experienced workmen. The hides are then put into cold water to "plump" them, and are then put into "handlers," or vats containing the tanning solution. After 12 days they are put into "layways," or vats, where the hides are piled, with bark spread between them, and which are then filled up with tanning liquor. The tanning liquor may be changed five times or more, depending on the grade of leather to be made, using stronger liquor each time. If the leather is to be used for belting butts, after passing through the "handlers" the bellies are trimmed off with sharp knives. The bellies are then used for making



PLAN, END AND FRONT ELEVATION OF VACUUM DRUM DRIER

sole leather. After a preliminary drying process the bellies, having gone through the layways, are dipped in water and oiled, and are then passed through a roller and rolled into sole leather—irregular-shaped strips about a foot wide and 6 ft. long. The sole leather goes to a drying loft.

After treatment in the layways the belting butts (or hides with the bellies and shoulders cut off) are oiled with cod oil, and then are hung up in a dry loft, or "tunnel," through which air is blown, and dried for ten days, the temperature of drying being gradually raised to 95-100 deg. F.

The tannery making leather for sale in the general market sells it by the pound. It is therefore to the advantage of the tannery to add weight to its product. This is done without any unnecessary display or advertising by allowing the hides to spend a long time in some of the processes, and under this method of procedure, which benefits the leather manufacturer but does not improve the quality of the leather, six months are consumed in transforming a hide into leather. . The complete process can, however, be done in two months; hence it is easy to see, from the greatly reduced amount of capital tied up in stock in process and the improved quality of material, the economies to be derived from the consolidation of a tannery with a factory for the production of finished leather goods.

The present capacity of the tannery is 125 hides per day, but under the new management this will soon be increased to 500 per day.

Lang-Grant Leather Corporation

As stated above, the tanning extract plant and the tannery have been purchased by the Lang-Grant Leather Corporation, which is now building and will operate, in conjunction with the existing plants, extensive additions to the present tannery, and a large new plant for the manufacture of harness, saddles, horse collars and gloves. The capital stock of the new company is $4,000,000. The enterprise will operate under the management of J. Harry Lang and R. Y. Grant. A site of 12 acres has been secured for the plant buildings. The building now being constructed is four stories high, 440 ft. long by 120 ft. wide, with two wings, 64 ft. by 50 ft., and 35 ft. by 70 ft. respectively, both three stories high. The building in which the saddlery will be manufactured will be 1200 ft. long by 100 ft. wide. The new buildings will be constructed of brick and concrete, the building materials being all made in Kingsport.

An idea of the magnitude of the proposed operations is gained from the statement that 400 tons of rye straw, locally grown, will be used annually in the production of horse collars alone. It is stated that the new enterprise when completed will employ 1200 to 1500 men, more than half of whom will be skilled mechanics. It can easily be realized that there is already great activity in the building of dwellings for housing the expected large increase in the population of the city.

Kingsport Pulp Corporation

The plant of the Kingsport Pulp Corporation was built in 1916-17, and was first operated in 1917. The capital stock of the company is $1,000,000. The principal officers are: President, Royal B. Embree; treasurer, J. C. Stone; general manager, J. H. Thickens; mill manager, J. E. Wetherbee. The plant was designed by George F. Hardy of New York City.

The reasons for the location of the plant at Kingsport, aside from the cheap power available, were existence of the tanning extract plant, which could supply 50 per cent of the raw material needed, in the form of extracted chestnut wood chips, and the abundance of hard woods in the vicinity, which would provide the other 50 per cent. The kinds of wood used, besides the chips from the extract plant, are poplar, cucumber and black and sweet gum. The capacity of the plant is 100 cords of wood a day.

The first step, as applied to the cord wood, is the stripping of the bark. This done, the wood goes to the chipper house, where it passes through a chipper made by the Carthage Machine Co., Carthage, N. Y., and under the chipper to a bucket elevator, which elevates the chips to a revolving screen, also manufactured by the Carthage Machine Co. This screen is a double one, and is shaped like the frustum of a cone, lying on its side. It is 30 ft. long by 4 ft. in diameter at the upper end, enlarging to 9 ft. at the lower end, and is placed at a pitch of 4 ft. in 30 ft. of length. The inner screen has meshes of 1½ in., the outer one, ¾ in. Sawdust escapes through the outer screen and goes to the boilers. The chips remaining on the inside of the inner screen go to a crusher, where they are reduced in size, and then join the chips which are caught between the two screens, going by conveyor to a bucket elevator, by which they are hoisted to the chip bins, which have a capacity of 100 cords of wood, or sufficient for one day's run.

The next step is digestion of the chips with caustic soda solution. There are ten digestors, built by the American Welding Co., of Carbondale, Pa., and made of seamless welded steel ⅝ in. thick, each 7 ft. in diameter by 30 ft. high. A solution of caustic soda is made, by treating soda ash with lime, in a Dorr system of tanks, six in all, each 30 ft. in diameter by 10 ft. deep. This is a continuous causticizing process. The strength of the solution as used in the digesters is 12 deg. B. The digester is charged with five cords of chips and 3500 gal. of caustic liquor, and is then sealed air tight.

The mass is then cooked with steam injected into the solution under a pressure of 110 lb. for 7¾ hours. At the end of that time the entire contents of the digester escape through a valve at the bottom into a blow-tower on the roof, being blown up there by the steam pressure in the digester. From the blow-tower the pulp goes to any one of four wash pans. These are of steel, and are 16 ft. in diameter by 7 ft. deep, fitted with a perforated false bottom which allows the liquor to drain off and retains all the pulp. The liquor goes back to the recovery process for the recovery of caustic soda. The pulp is washed for five or six hours, and is then delivered to the screen room. The wash water is discharged into the sewer.

The screen room contains eight screens, which are rectangular boxes about 10 ft. long by 4 ft. wide by 1 ft. deep, whose bottoms consist of ten brass plates, each a foot wide, containing many narrow slits 4½ in. long by 10/1000 in. in width. This screen, called the Improved Packer Pulp Screen, is made at Hudson Falls, N. Y. The wood fiber is drawn through the narrow slits by vacuum, the vacuum being alternately applied and released 700 times a minute by special machinery. All the fiber suitable for pulp making goes through the slits, and the oversize is rejected and goes to waste.

The material passing through the screen consists of 99.5 per cent water and 0.5 per cent fiber. This liquid goes through an iron pipe to one of two Decker-Wet

machines, manufactured by the Thompson Manufacturing Co., Lancaster, N. H. Here all trace of soda ash, lime, etc., is washed out, and the mass is brought to a concentration of 90 per cent water and 10 per cent fiber. The pulp now goes to the Belmer bleachers, of which there are six, manufactured by the Thorn & White Co., Philadelphia, Pa. Here a bleaching powder solution, 3.5 deg. B. in strength, is added. The function of the Belmer machine is to cause a continuous circulation of the stock through a system of tanks, during the bleaching process, which requires about five hours. After the bleaching is completed, the stock is dumped into one long tank, which extends under all six of the bleachers. The stock is then washed again, over a triple Decker-Wet machine, and then goes to a pulp-drying machine built by J. H. Horne & Sons Co., Lawrence, Mass. Here the pulp passes through an elaborate system of rolls, some of them steam-heated, by which it is dried, and is then cut into suitable sizes and rolled into bundles suitable for shipment.

The output of this plant is 50 tons of pulp a day. The quality made is excellent, the color a pure white, and it is used by paper makers for the manufacture of calendared paper such as is used by the better class of magazines.

Recovery of Caustic Soda

The liquor escaping from the false-bottomed tanks in the wash room is piped to two Yaryan evaporators, made by the Yaryan Co. of New York City. This type of evaporator is a 22-coil, triple effect machine. The first effect operates under 30-lb. pressure, the second effect under 9 in. of vacuum, and the third effect under 24 in. of vacuum. The solution enters the evaporator at 5 deg. B., and is discharged at 35 deg. B. It then goes by pipe line to a tank, and thence flows to one of two incinerators, where all water is expelled and the mass is burned to black ash. The incinerator is a revolving steel cylinder, on its side, 12 ft. in diameter by 15 ft. long, lined with 8 in. of fire brick. The woody matter of the caustic solution is burned at a very high temperature, said to be 2500 to 2800 deg. F. The recovery of black ash per day amounts to 60,000 lb., equivalent to 75 to 90 per cent of the caustic soda used. The black ash is distributed to leaching cells, where it is leached under 25 lb. pressure, and the solution is returned to the causticizing room, where it is used in the production of cooking solution.

The recovered solution as received at the mixing tanks in the causticizing room is of various strengths. Quicklime and soda ash are added to bring the solution to the strength desired. For mixing the caustic solution there are three steel mixing tanks, 9 ft. deep by 11 ft. in diameter, each provided with agitators, and perforated basket for slaking the lime. When the solution strength is properly adjusted, it goes to the Dorr system of tanks previously described.

The proper proportions for making caustic soda, assuming no recovered black ash solution to be used, are 5500 lb. of soda ash to 5650 lb. of quicklime. The quicklime is obtained from the neighboring plant of the Clinchfield Portland Cement Co. The actual consumption of quicklime per day is 50,000 to 55,000 lb., and of soda ash, 12,000 to 15,000 lb., the consumption of the latter being greatly reduced by the use of recovered black ash.

This concludes the description, necessarily brief and incomplete, of Kingsport and its chemical industries. One can hardly fail to notice how the plants are linked to one another. The utilities company supplies all the plants with power, and with water for drinking and fire purposes. The brick and cement companies supply themselves and all the rest with building materials. The dye works produces dye for the hosiery mill, and bleaching powder for the pulp mill. The cement plant furnishes lime for the industrial alcohol plant, the dye works, the tannery and the pulp mill. The extract plant supplies tanning extract for the tannery and extracted wood chips for the pulp mill, and the tannery will provide the new saddlery and harness factory with leather. If co-operation is the life of trade, the industries of Kingsport should thrive indeed.

Opportunity must be taken here to express appreciation of the courtesies extended by J. Fred Johnson, president of the Kingsport Improvement Corporation; by S. P. Platt, assistant to Mr. Johnson, and by the several managers and superintendents of the Kingsport plants who made possible this description of the chemical industries of an interesting community.

Imports and Exports

The Bureau of Foreign and Domestic Commerce of the U. S. Department of Commerce reports for March, 1919:

IMPORTS OF LEAD AND ZINC INTO THE U. S. BY COUNTRIES, AND FOREIGN AND DOMESTIC EXPORTS FROM THE U. S. TO ALL COUNTRIES

Articles and Countries	Imports Gross Weight, Tons	Contents, Lb.	Value
Lead ore:			
Canada	1,151	1,329,994	$52,704
Mexico	1,485	164,098	7,479
Peru	40	18,402	1,025
Total	2,676	1,512,494	$61,208
	Lb.	Lb.	Value
Lead and bullion and base bullion:			
Mexico	8,215,349	7,937,167	$317,106
Lead pigs, bars and old:			
Canada	.....	52	3
Mexico	.....	602,178	30,072
Jamaica	.....	12,896	523
Chile	.....	8,399	144
Total	.....	623,525	30,742
	Tons	Lb.	Value
Zinc ore and calcamine:			
Canada	540	358,605	$7,940
Mexico	2,163	1,455,537	17,760
Total	2,703	1,814,142	25,700
		Lb.	Value
Zinc Dust:			
England	.....	6,720	$1,270
Foreign Exports	Tons	Lb.	Value
Lead bullion and base bullion	.....	.....	.....
Lead pigs and bars	.....	709,435	$40,761
Zinc ore and calcamine	.....	.....	.....
Zinc blocks or pigs and old	.....	.....	.....
Zinc dust	.....	.....	.....
Domestic Exports		Lb.	Value
Lead pigs, domestic ore		4,289,414	$254,668
Lead pigs, foreign ore		2,635,524	147,051
Zinc spelter, domestic ore		14,373,192	1,172,939
Zinc spelter, foreign ore		1,786,277	171,266
Zinc in sheets		5,368,115	762,904

IMPORTS OF TUNGSTEN-BEARING ORES INTO THE U. S. BY COUNTRIES—DOMESTIC EXPORTS OF TUNGSTEN AND FERROTUNGSTEN FROM THE U. S. TO ALL COUNTRIES

Imports of Tungsten-Bearing Ores			Exports of Tungsten and Ferro-Tungsten		
Countries	Tons	Value	Countries	Lb.	Value
Chile	24	$20,818	Switzerland	1,400	$4,500
Peru	38	37,486	Canada	2,596	10,070
China	98	51,405	Australia	43	100
Hongkong	504	502,523			
Japan	11	13,388	Total	4,039	$14,670
Total	675	$625,620			

Synopsis of Recent Chemical and Metallurgical Literature

Electrometallurgy of Molybdenum.—According to an article by J. ESCARD in the *Revue Générale de l'Electricité*, Vol. IV, No. 11, Sept. 14, 1918, molybdenite, MoS_2, is treated in an electric furnace for molybdenum either directly or with molybdenum dioxide.

I. Direct Treatment of Molybdenite. The molybdenite is simply heated in an electric furnace and a fairly pure molybdenum is obtained. In heating a mixture of molybdenite and molybdenum dioxide in the electric furnace the following reaction takes place:

$$MoS_2 + 2MoO_2 = 3Mo + 2SO_2$$

and the product obtained has about 98.5 per cent Mo, with only about 0.7 per cent sulphur. When the mixture of molybdenite, carbon and lime is heated in the electric furnace the reaction is:

$$MoS_2 + 2C + 2CaO = Mo + 2CaS + 2CO$$

but this molybdenum still contains 3 to 4 per cent sulphur. When treating in a resistance furnace a mixture of molybdenite, lime and calcium fluoride, the product obtained is Mo_2S_3 if the current is high, 600 to 800 amperes and 110 volts, but with a current of 70 to 100 amperes and about 35 volts, and eliminating the iron with hydrochloric acid, the product obtained is 98.95 per cent Mo and 0.67 per cent Fe.

II. Treatment of Molybdenum Dioxide. The molybdenum dioxide is reduced with carbon. The following reactions take place:

$$2MoO_2 + 5C = CMo_2 + 4CO$$
$$2CMo_2 + MoO_2 = 5Mo + 2CO$$

The product obtained has one of the following compositions:

	No. 1	No. 2	No. 3
Molybdenum	99.98	99.73	99.78
Carbon	0.00	0.01	0.00
Slag	0.13	0.28	0.17
	100.11	100.02	99.95

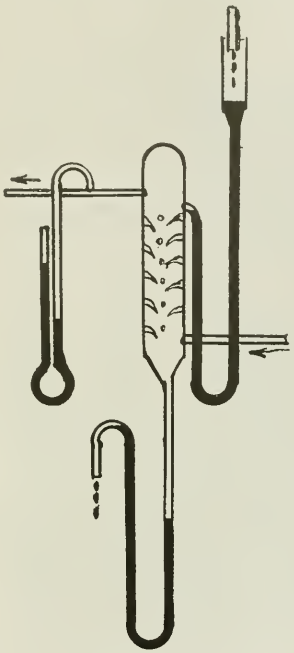
The molybdenum dioxide can be replaced by calcium molybdate in the presence of alumina when admixed with molybdenum carbide, as per the reaction

$$9CMo_2 + 3MoO_4Ca + Al_2O_3 = 21Mo + Al_2O_3 \cdot 3CaO + 9CO$$

In the preparation of electric wires the carbon filaments are subjected to the thermic action of an electric current in the presence of hydrogen in an atmosphere of molybdenum pentachloride ($MoCl_5$). This is transformed into molybdenum carbide, then finely pulverized molybdenum dioxide is added and the same reaction as above takes place, giving the pure molybdenum metal.

Continuous Testing of Gas With Special Reference to Acid or Alkaline Constituents.—In the course of working a plant for the recovery of ammonia from Mond gas, the need was felt for some form of apparatus which would indicate at any time whether complete absorption of ammonia was being effected, or whether some ammonia was passing through the plant, with consequent loss in the recovery of ammonium sulphate. The apparatus devised is described by C. A. KING in the *Journal of the Society of Chemical Industry*, London, England, Feb. 15, 1919, which serves for the continuous testing of alkalinity or neutrality of a gas.

The gas from the outlet main is caused to pass upward toward a small glass absorption chamber about 7 cm. long and 1.5 cm. diameter, provided with projections from the inner wall to effect more efficient contact with a solution of a suitable indicator which flows from a U-shaped tube into the upper end of the extraction chamber. The indicator solution drains away from the lower end of the absorption chamber through a similarly shaped tube in which any change in color of the solution is noted. The inlet and outlet bends are of such length that the solution forms a liquid lute against the pressure of the gas in the apparatus.



APPARATUS FOR CONTINUOUS TESTING OF GAS

The indicator used is a solution of methyl red with sufficient acid added just to develop the true red color of the acid indicator. The color change from red to yellow (in alkaline solution) can be readily observed by artificial light. Complete absorption of ammonia takes place with a flow of gas through a 2-mm. diameter jet (about 5 cu.ft. per minute), and with the indicator solution set at a fast dropping rate a very sensitive indication can be obtained.

The apparatus is used qualitatively, but with suitable calibration it might be employed for approximate quantitative estimation. It is suggested that a similar form of apparatus might be conveniently used for other purposes, for example the detection of acid vapors in chimney gases. But it can only be used where colorimetric tests can be applied owing to the fouling of the observation tube by anything in the nature of an adherent precipitate. Another possible application is for the detection of CO using the iodine pentoxide method in which the iodine liberated is absorbed by a continuous stream of potassium iodide solution to which are added a few drops of starch solution as an indicator. The arrangement as shown is made especially to obviate siphoning of the entering liquid, though under certain conditions siphoning at intervals might be a distinct advantage.

Mechanical, Micrographic and Macrographic Properties of Alloys High in Zinc.—MESSRS. LEON GUILLET and VICTOR BERNARD have studied mechanically, micrographically and macrographically the alloys high in zinc (*Revue de Metallurgie*, 15, No. 5, Sept.-Oct., 1918). Their aims were: 1. To determine the influence of copper and aluminium on the properties of zinc. 2. To examine some ternary alloys Zn-Cu-Al. 3. To study

the variation of the properties of the alloys with temperature, and to determine the temperature optimum for their forging and working.

A. The results of the mechanical tests are summarized as follows:

According to the purity of the zinc, and especially with its content of lead, the mechanical properties of rolled zinc are:

Breaking strain $R = 15$ to 16 kg.
Extension $A = 35$ to 47 per cent

The cast alloys do not present any interesting feature. An alloy with 8 per cent copper has a breaking strain of 17 kg., but the elongation and resilience are nil. A rolled alloy of 3 per cent aluminium has a breaking strain of 23 kg. and an elongation of 15 per cent. A rolled alloy of 2 per cent aluminium and 3.6 per cent copper has a breaking strain of 32 kg. and an elongation of 5 per cent. When drawn down the alloys generally show a higher breaking strain and a greatly increased elongation. Thus:

Alloys		Breaking Strain R	Elongation, Per Cent A	Resilience S
2.5 per cent Al	Rolled	22.0	4.4	1.2
	Drawn	25.9	26.4	2.5
1.3 per cent Cu	Rolled	23.0	1.5	1.8
	Drawn	30.5	27.9	1.9
4.2 per cent Cu	Rolled	30.5	7.3	1.2
	Drawn	33.5	22.0	1.6
2.1 per cent Al, 3.6 per cent Cu	Rolled	32.1	4.4	1.2
	Drawn	37.4	16.1	1.2

The drawn alloys possessing somewhat similar mechanical properties to drawn brass ($R = 28$ to 32 kg. $A = 30$ to 25 per cent, $S = 3$ to 5) are:

Alloy: Ordinary zinc (1 to 1.2 per cent Pb) 97.5 per cent to 98 per cent, copper 1.5 per cent to 2 per cent with $R = 30$ to 31 kg., $A = 27$ to 28 per cent, $S = 2$.

Alloy: Ordinary zinc (1 to 1.2 per cent Pb) 88 per cent, copper 4 per cent, aluminium 8 per cent with $R = 36$ kg., $A = 24$ per cent, $S = 1.2$. It is to be noted that the resilience of these alloys is much smaller than that of brass.

B. The results of the micrographic examinations are summarized as follows:

Zinc-aluminium alloys. These two metals form two solid solutions, one containing 0 to 4 per cent Al and the second from 50 to 100 per cent Al. These two solutions form a eutectic which corresponds to 5 per cent Al. It has been found that a eutectic is formed in an alloy with only 1 per cent Al. This is probably due to heterogeneity of the alloy.

Zinc-copper alloys. In these alloys there is a solid solution η when the percentage of copper is at the most 2.5 and two solid solutions, one η and another ε, when the percentage of copper is between 2.5 and 13. The solution ε increases with the percentage of copper; it gives rise to brittleness and its formation should be avoided by limiting the percentage of copper.

Zinc-aluminium-copper alloys. A complete examination of the Zn-Al-Cu alloys has not yet been made, but it appears that the solid solutions of zinc with aluminium and of zinc with copper are formed independently. The constituent ε increases with the percentage of copper, the eutectic also increases. The properties of the alloys correspond with the separate properties of these solutions. This explains the remarkable properties of the alloy zinc 88 per cent, aluminium 8 per cent, copper 4 per cent, in which the eutectic of the two solutions predominates (to which correspond the properties $R = 27$ and $A = 27$ per cent) and a certain quantity of ε which increases the hardness.

C. The results of the macrographic examinations are summarized as follows:

1. In cast samples the macrographic examination reveals large elongated crystals. The constituents observed in the micrographical examination are generally visible and sometimes distributed heterogeneously. 2. In rolled samples the crystal structure is not apparent, but the heterogeneity is often revealed. 3. In drawn samples the transverse as well as the longitudinal sections show defaults of homegeneity in the center. They cannot be eliminated by annealing. This point deserves careful consideration. The mechanical properties of the alloys vary with the temperature, the elasticity increasing very rapidly between 100 deg. C. and 150 deg. C. The optimum temperature for forging and working the alloys is 125 to 130 deg. C.

The conclusion is that of all the alloys high in zinc only two deserve special attention, namely:

Alloy: Ordinary zinc 98 per cent, copper 2 per cent, with $R = 30$, $A = 28$ per cent, $S = 1.9$.

Alloy: Ordinary zinc 88 per cent, copper 4 per cent, aluminium 8 per cent, with $R = 36$, $A = 24$ per cent, $S = 1.2$.

Electrometallurgical Treatment of Nickel Ores in New Caledonia.—The electrometallurgical treatment of the New Caledonia nickel ores has not given satisfactory results until lately in regard to the production of a ferronickel low in carbon and silicon. Mr. M. SABATHIER gives in the *Journal du Four Electrique*, 28, No. 1, Jan. 1, 1919, the method used at Taô, on the eastern coast of New Caledonia, for treating garnierite in an electric furnace, by which he obtained a product containing less than 0.5 per cent carbon and about 0.2 per cent silicon.

The ore treated is a garnierite of the following composition:

	Per Cent		Per Cent
SiO_2	53.10	Al_2O_3	0.50
NiO	6.62 (5.20 Ni)	CaO	1.70
		MgO	15.30
Fe_2O_3	12.68 (8.85 Fe)	Loss on ignition	9.90
			99.80

The principle of the method is to heat the ore with carbon, whereby the total nickel oxide and part of the iron oxide are reduced; the non-reduced iron oxide becomes a part of the slag, while the reduction of silica is avoided by the use of lime giving a basic slag. The charge is composed of:

(a) Run of mine ore, which contains 20 to 25 per cent moisture.

(b) Powdered charcoal in a well-defined porportion to reduce the total nickel oxide and part of the iron oxide.

(c) Lime in proportions to give a basic slag.

A 400-kw. furnace is used. Two electrodes are used which are in series. The product obtained is a ferronickel of 50 per cent Ni with a maximum of 0.5 per cent C (the usual percentage being about 0.05 per cent C) and about 0.2 per cent silicon.

The electric energy consumed per ton of ferronickel 50 per cent Ni is 13,000 kw.-hr., with electrode consumption of 125 kg. There is a 2 to 3 per cent loss of nickel in the slag. When producing a ferronickel of 75 per cent Ni the carbon percentage is even smaller than for the 50 per cent Ni ferronickel, the percentage of silicon is the same, which is about 0.2 per cent, but the loss of nickel in the slag is 4 to 5 per cent of the total nickel in the charge.

Recent Chemical and Metallurgical Patents

Briquetting Brittle Metals.—F. A. VOGEL of New York City notes that the Ronay system of briquetting operates very well on many metals, but does not press brittle borings into a coherent mass. The Ronay process operates in such a manner as to cause attrition between contiguous metallic surfaces under conditions which exclude air or other film. Molecular cohesion then seems to unify the particles into almost an integral mass. Borings or turnings of steel are usually covered with oil, soap or other foreign matter which tends to prevent such particles from coming into direct contact. Brittle borings are, therefore, first reduced in size by grinding in an edge runner and then heated to a point which not only will burn any carbanaceous foreign material, but also after a slow cooling will bring the particles into a dead-soft anneal. Thereupon such metallic particles can be made into coherent briquets by the Ronay system. (1,299,878; assigned to General Briquetting Co., Apr. 8, 1919.)

Zinc Leaching.—H. L. SULMAN and H. F. K. PICARD of London, England, note that in the leaching of oxidized or roasted zinc ore with sulphuric acid it is extremely difficult to neutralize the last amounts of free acid solely by agitation with ore. They, therefore, propose to start with a solution containing approximately 10 per cent of sulphuric acid, and when the free acid has been reduced to from 1 to 2 per cent by successive additions of ore, the neutralization is completed by zinc hydrate. This pulp is then agitated at a high temperature to precipitate soluble silica in granular form when the zinc solution is separated from the various insolubles by filtering in the ordinary way. The filter cake still contains considerable soluble zinc which is removed by wash water—this wash water, however, is not added to the original solution, but is agitated with milk of lime. In this manner zinc hydrate and calcium sulphate are precipitated from the solution and are used as above noted to neutralize residual acidity in the leaching solution. (1,295,080; assigned to the Metals Extraction Corporation, Ltd., of London, England, Feb. 18, 1919.

High-Phosphorus Slag.—WILLIAM R. WALKER of New York City notes that American iron ores are so low in phosphorus that when the resulting pig iron is refined, the resulting slag is very low in phosphates, owing to the fact that so much lime must be added to flux the silicon. In order to produce phosphate slag containing at least 13 per cent of soluble phosphates, he first treats the iron in an acid bessemer converter. Here the silicon is reduced to small traces and the skimmed metal then transferred to a refining furnace, such as an open-hearth or an electric furnace. A basic slag is then made up which rapidly absorbs phosphorus from the bath. When the slag contains the greater part of the phosphorus, as much of it is withdrawn as is convenient and a second or finishing slag is added to complete the refining operation. The first slag may contain upward of 18 per cent phosphate, soluble in citric, and is therefore available as a fertilizer. The second slag is relatively low in phosphorus, but is high enough in calcium and iron so that it can be recharged in a blast furnace, thus recovering its phosphorus. (1,299,072; Apr. 1, 1919.)

Hardening-Machine.—C. C. JACKMAN and R. S. SQUIRE of Springfield, Mass., have patented a hardening machine especially adapted for the treatment of continuous objects such as wire or other long narrow objects which can be linked together in a continuous chain. During hardening such a chain is passed

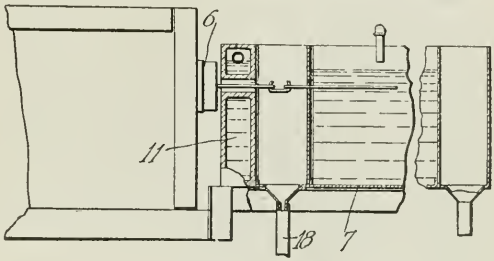
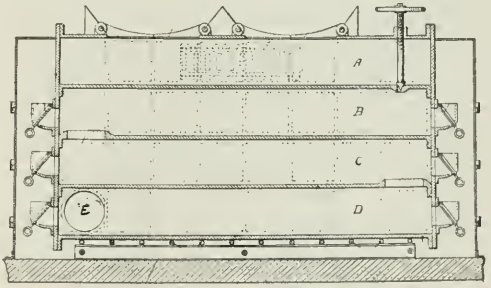


FIG. 1. HARDENING MACHINE

through an annular heating furnace of correct design, and on emerging from the furnace at 6 (Fig. 1) passes directly into the quenching tank 7. The quenching oil necessarily flows out of the tank through the slot by which the heated metal enters. Such oil is drained off through pipe 18, but the spray thrown up by this spashing oil has in the past quite often caught fire from the red-hot furnace, with disastrous results. The inventors, therefore, interpose between quenching tank and furnace the water-cooled jacket 11, which effectually prevents such fires. (1,299,949; assigned to Massachusetts Saw Works, Apr. 8, 1919.)

Down-Draft Sulphur Burner.—The burner shown in the accompanying illustration consists of four chambers, *A*, *B*, *C*, *D*. The uppermost, *A*, serves as a supply chamber for the sulphur, which is melted by the heat



DOWN-DRAFT SULPHUR BURNER

of the burning sulphur below. By means of the valve, liquid sulphur is run into the lower compartments which are connected by the openings shown at the left and right ends, respectively, of *B* and *C*. Since the upper rim of these openings is raised, a layer of melted sulphur will be retained in *B* and *C*, while the excess will collect in *D*. Air is supplied through the adjustable dampers, three of which are shown at each end, and the sulphur dioxide is drawn out through the pipes, *E*. Thus the sulphur dioxide takes the course which it would naturally pursue, since it is heavier than air. The whole furnace is surrounded by a jacket having sliding

dampers (shown in dotted lines in the center of *A*) through which the air supply must pass while the burner is in operation, the object being to preheat the air by contact with the hot walls. Numerous peepholes are provided so that the color of the flame may be observed and the air regulated accordingly. It is claimed that sublimation is avoided by this construction. (1,303,348; AINWELL G. MCINTYRE; May 13, 1919.)

Aniline Hydrochloride.—Since aniline hydrochloride is less soluble than aniline in benzene, toluene, carbon tetrachloride and similar solvents, the hydrochloride is obtained as a pure white precipitate when dry hydrogen chloride is passed into or over a solution of aniline in any of these solvents. CHARLES AHLUM of Chester, Pa., claims that this process not only gives a lighter colored product, but also obviates the necessity of repeated filtrations and concentrations, with their accompanying losses due to decomposition of the salt and the frequent handling required. (1,303,624; assigned to E. I. du Pont de Nemours & Co.; May 13, 1919.)

Spur Gear Speed Reducer

GEAR speed reducers are being employed extensively for driving elevators, conveyors, driers, pumps, agitators, mixers, screens and many other classes of machinery where it is customary to use a considerable reduction in speed between the motor and driven unit. They have also found a useful application and have rapidly gained favor for line-shaft service. On many belt-driven line-shaft installations, the main line drive pulley is nearly double the size of any other pulley on the shaft, which makes it necessary to provide hangers of sufficient depth to clear the drive pulley, while if a gear speed reducer were used it would be possible to use shorter hangers throughout the entire length of the line shaft, thus making an initial saving, besides providing a much more rigid drive as well as effecting a saving in overhead space.

Although for line-shaft drives the ratio is comparatively low, rarely exceeding 9 to 1, the first cost of the speed reducer will often be less than for any other complete drive, taking everything into consideration. Besides this, it will frequently be found practicable to use high speed motors, which are less expensive than slow speed motors and are generally more efficient.

The W. A. Jones Foundry & Machine Co. of Chicago manufactures a single and double type speed reducer, the single having reductions up to 15 to 1 and the double up to 200 to 1. Standard equipments as high as 200 hp. are built. The high and low speed shafts are concentric, joined through a flexible coupling and have the same rotating direction.

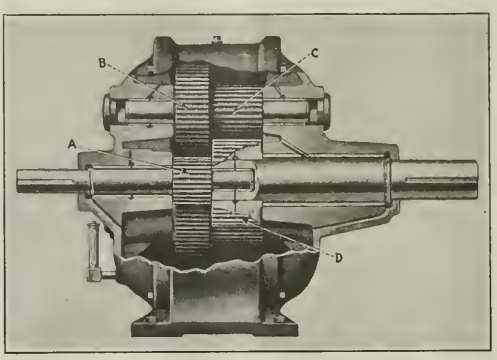
A few of the advantages claimed for these reducers are:

1. They occupy less space than other devices necessary to accomplish the same ratio of speed reduction.
2. Acid fumes, abrasive dust or other adverse atmospheric conditions do not affect their successful operation.
3. Shafts and bearings are relieved of all cross strains and transverse loads.
4. Slide rails and adjustments for correct center distances are unnecessary.
5. They require practically no attention and are quiet, efficient and durable.
6. The decrease installation costs.
7. All safety laws are complied with: There are no exposed moving parts that will cause injury to workmen.

Referring to the accompanying illustration, it will be seen that the pinion *A* meshes with and drives the three gears *B* which are mounted integral with the three pinions *C*. These in turn mesh and drive the slow speed gear *D*.

The gears *B* and pinions *C* are equally spaced around the high and slow speed pinion and gear at angles of 120 degrees, thus relieving both high and slow speed shafts and bearings of all transverse loads due to tooth thrust.

The high speed shaft and pinion *A* are forged from one piece of special analysis nickel steel. The pinion *A* is amply supported in correct alignment at one end by the bronze bushed bearing in the reducer housing,



SPUR GEAR SPEED REDUCER

and on the other end by the slow speed shaft extension which carries a bushed bearing.

All gears and pinions are finished from steel forgings, the accurately generated teeth being of the involute stub form with 20 deg. pressure angle, which insures great strength, maximum efficiency and long life. All shafts are accurately ground to size and are supported in heavy bronze bushed bearings, which insures correct alignment and proper meshing of the gear teeth. The splash system of lubrication automatically insures a copious supply of lubricant at all times.

Personal

MR. WALTER ARTHUR, formerly chief chemist and metallurgist with the Garfield Motor Truck Co., Lima, Ohio, has accepted a similar position with the Haynes Automobile Co., Kokomo, Ind.

MR. C. D. BALL, JR., has been discharged from the Chemical Warfare Service and resumed his duties as instructor in chemistry at the Michigan Agricultural College, East Lansing, Mich.

MR. RALPH V. DAVIES is now in the technical control department of the Aluminum Co. of America, New Kensington, Pa.

MR. F. W. DEARBORN, formerly of the Ordnance Department, is now on the staff of the Bureau of Standards, where he will be engaged especially in research on the chemistry of cellulose.

MR. JOHN T. FULLER has accepted a position with the American Bauxite Co., Bauxite, Ark.

Dr. John A. Mathews, president of the Halcomb Steel Co., Syracuse, N. Y., sailed for Europe recently as a member of the War Department's Aircraft Standardization Committee, headed by Assistant Secretary Crowell, to study the standardization in aircraft building in Europe.

Mr. H. W. Morse gave an illustrated talk before the San Francisco section of the American Chemical Society on May 19 on the manufacture of potash and borax at Searles Lake, California.

Mr. Floyd W. Parsons has resigned as editor of *Coal Age* to accept a position with the *Saturday Evening Post* as head of the business and science department.

Mr. S. F. Shaw has accepted a position as superintendent of the Charcas Unit, National Metallurgical Co., Charcas, Mexico.

Dr. William H. Walker has received his discharge from the United States Army and is returning to civil life at his home in Bridgton, Me. Dr. Walker was commissioned Colonel in the Chemical Warfare Service and had charge of the Edgewood Arsenal.

Prof. Waturo Watanabe has retired from the post of professor of mining and metallurgy, as well as the director of the Engineering College, and has been elected emeritus professor of the Imperial University, Tokyo, Japan.

Mr. Robert E. Wilson has accepted a position as assistant director of the research laboratory of applied chemistry and assistant professor of chemical engineering in the Massachusetts Institute of Technology, Cambridge, Mass.

Mr. Louis E. Wise, formerly of the Bureau of Chemistry, has resigned to accept a position with E. I. du Pont de Nemours & Co., Wilmington, Del., as organic research chemist.

Mr. Harry J. Wolf has resigned his position as professor of mining, Colorado School of Mines, to accept a position on the editorial staff of the *Engineering and Mining Journal*.

A State Bureau of Mines at Butte has been organized with Mr. C. H. Clapp as director and geologist, Mr. H. B. Pulsifer as metallurgist and Mr. A. E. Adami in charge of the department of mining engineering.

Current Market Reports

The Non-Ferrous Metal Market

Tuesday, June 10.—Prices have taken a firm tone. Copper appears to have gained its normal market equilibrium and will probably not fluctuate much above or below 17½c. in the near future.

Aluminium:—A good volume of business is reported at 33c. per lb. on 98-99 per cent ingots. Scrap sales are reported as follows: Cast, 20-23c.; sheet, 20-23c.; clippings, 22½-26c. Sheets 18 gage and heavier, 42c. Powder, $0.70-1.40 lb.

Antimony:—There is a slight shortage in antimony supplies, wholesale spot bringing 8¾c. and future 8-8¼c. lb. Job lots, 8⅝c. lb.

Copper:—The advance in copper has settled at 17⅜-17½c. lb. with no lower offers on futures. Scrap is bringing from 12 to 16c.

Copper sheets, hot-rolled	lb.	$0.24	— .....
Copper sheets, cold rolled	lb.	.25	— .....
Copper bottoms	lb.	.23½	— .....
Copper rods	lb.	.21	— .....
Copper wire	lb.	.18	— $0.18½
High brass wire and sheets	lb.	.19½	— .....
High brass rods	lb.	.18½	— .....
Low brass wire and sheets	lb.	.21½	— .....
Low brass rods	lb.	.22½	— .....
Brazed brass tubing	lb.	.30½	— .....
Brazed bronze tubing	lb.	.35	— .....
Seamless copper tubing	lb.	.29	— .....
Seamless bronze tubing	lb.	.35	— .....
Seamless brass tubing	lb.	.30	— .....
Bronze (gold) powder	lb.	1.00	— .....

Lead:—Lead is very stable. New York asks 5½c. and E. St. Louis 5c. lb. Sheet lead has advanced to 8¼c. lb.

Tin:—A complete liquidation of the 72½c. tin allocation is expected in the fore part of July.

Zinc:—Spelter has had a slight rise in New York, to 6⅝c., with futures up to 6¾c.; E. St. Louis, 6¼c. with August futures at 6½c.

OTHER METALS

Bismuth	lb.	$3.20	— $3.65
Cadmium	lb.	1.40	— .....
Cobalt	lb.	2.50	— 3.50
Magnesium	lb.	1.75	— 2.10
Mercury	75 lb.	92.00	— .....
Nickel	lb.	.40	— .45
Iridium	oz.	175.00	— .....
Palladium	oz.	115.00	— 120.00
Platinum	oz.	105.00	— .....
Silver	oz.	1.10⅜	— .....

The Iron and Steel Market

The improvement in steel demand that began May 10 or 15 and made good progress during the second half of the month gained only a little additional headway during the first half of June. There was no retrogression, however, in any branch of the finished steel trade, and demand for some products, particularly sheets and merchant steel pipe, increased very considerably.

It is the common opinion that the movement has not gained sufficient momentum to carry it through what is normally the dull summer period. In recent years it was only in 1915 that there was a really active market in July and August, and in that year the foundation for the greatest rise in steel market history was being laid. Should the steel market become relatively dull in July and August, however, the probability would be of a fresh movement starting in early autumn of greater proportions than the one now being experienced.

Production Heavier

Production of pig iron during the first half of June was at a rate of fully 25,000,000 tons per annum, or a rate slightly in excess of the rate in the latter part of May. Up to that time there had been a continuous decrease in pig iron production, but the turn seems to have occurred. High humidity in the midsummer period would decrease the rate of production as to the furnaces actually in blast, but such a decrease would be only a temporary and seasonal affair. Pig iron production at 25,000,000 tons a year means 58 per cent of capacity if capacity be taken at 43,000,000 tons a year, and 56 per cent if capacity be taken at 45,000,000 tons. The actual commercial capacity probably lies within these limits. Steel ingot production is at approximately the same percentage of capacity. In the early months of the year pig iron production was at a much higher proportionate rate to capacity than was shown by steel. It is probable that steel mills having blast-furnaces were endeavoring to liquidate stocks of ore, while steel mills using purchased pig iron were endeavoring to work out contracts, thus using more than usual proportions of pig iron. With conditions fairly well liquidated in this respect, there is probably heavier consumption of scrap in steel making than formerly. Earlier in the year heavy melting steel scrap touched a low point of about $14.50, delivered Chicago, Pittsburgh or Philadelphia, there being scarcely any demand. At the beginning of June the market was approximately $16, and in the fore part of the month the Pittsburgh market advanced to $17. Scrap dealers describe the market as dull, but there has probably been quite heavy absorption of scrap, both by direct purchases of mills from railroads and other producers and by purchases of Government scrap lying in the mills' own yards.

Character of Demand

Those who doubt whether the steel trade can become really active until there is a radical change in conditions point to the fact that there is no railroad buying, and not likely to be any for deliveries this side of next spring, and also urge that there is little new construction work being undertaken, while railroad demand and general construction work always absorb much more than half the steel output when there is production at capacity. The theory seems plausible enough at first glance, but when one takes notice of the fact that the mills have been operating at 55 per cent or more of capacity he wonders how that can occur if more than half the steel demand is missing. When the operating rate is 55 per cent, the more customers there

are who are out of the market the better, for at some time or other they would have to come in, and there might not be room for them. The probability is that a fair amount of construction work is in progress despite the general appearance of dullness in that direction.

A factor in the present steel situation should be noted, that while in ordinary periods of activity there is well distributed demand from all quarters, the period of activity upon which the steel trade must enter at one time or another represents an accumulation of demand and it is not necessary that all classes of consumers should be equally active throughout this period of activity. Some consumers may fill the major portion of their accumulated requirements in a short time, others may buy little in the near future but a great deal more in the later future.

Steel Prices

It is a question whether there is more or less shading of steel prices now than there was before the recent increase in activity. The demand is not heavy enough to firm up prices, while when there is more inquiry there is more temptation to cut prices. Where there is shading, however, it rarely amounts to more than from $1 to $4 a ton, and the general foundation of the market is much firmer in this respect, that the cutting does not precipitate a break. Earlier in the year it was the feeling of many if not all steel producers that any yielding in the market would precipitate not merely a decline but a serious break. The whole bottom might drop out of the market. Nothing of the sort is now feared. The market is standing more or less on its own feet.

Pig Iron

Technically there has been an open market in pig iron since about April 1. It has been necessary for pig iron to adjust itself to commercial conditions, for the war-time price structure was altogether artificial. The normal condition is for pig iron to sell at higher prices in some producing districts than in others, according to variations in cost of production and the amount of pig iron that can be disposed of within a certain freight radius. Birmingham iron, for instance, has always had to penetrate into Northern markets and compete with Northern furnaces, and thus prices f.o.b. Birmingham were always lower than prices f.o.b. Chicago, Ironton, eastern Pennsylvania and other furnaces. The war control, however, gave Birmingham the full f.o.b. furnace basis. The $3 reduction in December, 1918, and the $4.25 reduction proclaimed as effective March 21 did not touch the war-time basings. Birmingham iron has now declined so as to be more or less competitive with Northern iron. The March 21 price on foundry iron 1.75 to 2.25 per cent silicon was $26.75, while Birmingham iron is now available at $23.50, furnace. Some of the Lake front furnaces have cut prices in order to sell in distant markets, while endeavoring to hold prices as to their own local markets, and the same is true of southern Ohio furnaces. Taking the pig iron market as a whole, however, the decline has been very slight and it is quite improbable that there will be any large decline in the near future. The merchant furnaces have met the situation of light demand by blowing out. Predictions are beginning to be made of advances for pig iron in the near future, but such predictions are not in keeping with market history. When there are many furnaces out the pig iron market experiences the greatest difficulty in scoring an actual advance. At successive intervals idle furnaces come into blast, each furnace first selling some pig iron at any price obtainable to furnish the desired "back log."

General Chemicals

New York, June 9, 1919.

The firmer tendency noticeable is due in great part to the increasing influence of manufacturers. Many chemicals which have been selling in second hands at a figure far below the present cost of production are now entirely absorbed, leaving manufacturers largely in control of the situation. Particularly is this true of caustic soda, soda ash, bleaching powder and barium carbonate. Export inquiries continue in good volume. Spain, Denmark and South America show particularly satisfactory developments in this respect.

Large shipments of caustic soda continue to be made, Japan and South America being the heaviest buyers. This steady demand has absorbed material in second hands with a resulting stronger market. Acetic acid shows a decline, manufacturers having reduced their schedules to stimulate sales. Citric acid holds a much stronger position due to the recent warm weather and the consequent extra demand in the face of limited supplies.

Muriatic, sulphuric and nitric acids are receiving a good demand. Much of the muriatic is being shipped to Cuban sugar manufacturers, while the call for sulphuric comes chiefly from South America. Excess supply has caused pyrogallic to drop, being quoted now around $2.40 a pound.

Although most dealers have advanced slightly the price of bleach, there being no surplus stocks, one dealer is offering a lot of forty carloads at the low figure of $1.25 a cwt., New York.

Potassium carbonate shows an inclination to advance, some dealers having already jumped the price owing to demand from Denmark. Caustic potash remains unchanged, but is likely at any time to move in sympathy with potassium carbonate. Most of the potash products, however, are weak, owing to heavy competition with foreign goods.

When the Government relinquishes control of the price of sodium nitrate, on July 1, importers anticipate a reduction to $3.10 a cwt. from the present figure of $4.07½.

Coal-Tar Products:—The demand for crudes has increased during the interim and is confined almost entirely to domestic users. Benzol is particularly active with production cut. The price on pure water white is now 24-28c. per gal., the 90 per cent grade, 23½-27c. There will be little available spot stock of benzol until the close of July. Competition with the English product has caused a cut in cresylic acid.

The tendency on the part of intermediates to pick up, noted several weeks ago, continues and some manufacturers find difficulty in keeping up with the demand for some of the intermediates. The textile mills are beginning to consume dyes, with the result that dyemakers are increasing their demands for the coal-tar intermediates. Those receiving the heaviest call are alpha-naphthylamine, paratoluidine, paranitrotoluol and aniline oil. One manufacturer reports his entire output of paratoluidine promised to July on orders.

Waxes:—Most waxes have advanced in price. Spot stocks have been cleaned out with the result that offerings for shipment are light and the market is firm for futures.

Beeswax owes its advance to unprecedented demand and the limited arrivals of stock. The same with Japan wax.

A firm market in Brazil in conjunction with continued heavy demand here, in the face of a scanty supply, are the contributing factors in the jump of carnauba.

Although paraffine waxes have dropped still further in price, there is slight tendency toward a firmer tone. The difficulty with this commodity is that the demand by no means equals the production. However, it is believed that this condition will be overcome in a short time. A favorable sign is the increasing number of inquiries now coming from South America. Previously, the greater number of inquiries were from Europe. The demand from that source continues to hold fairly strong, while the domestic call is fair.

The recent warm weather has affected the production of stearic acid; causing an advance.

Oils: — Unabated European demand has continued to strengthen vegetable oils. England continues her heavy buying, with Sweden a close second. Domestic buyers are coming into the market for large quantities, apparently realizing that because of the huge export demand prices will undergo no reduction for some time.

There appears to be not so much a shortage of oils as that they are held in strong hands. This is attested to by the fact that several consignments of oils (part of the allocations made by the Government for Europe several weeks ago) were cancelled owing to late arrival at the docks and are now being held by the shippers. It is pre-

dicted, however, in some quarters that a scarcity may eventually be felt. For if England persists in her demand producers in the Orient will be likely to divert their supplies to the British market, thus forcing dealers here to rely on domestic crops, which may or may not meet the demand.

The expected advance in linseed oil has materialized and most dealers have increased previous quotations by three cents. The main factor in this condition is the scarcity of seeds and, in addition, dock strikes in Argentina have held up shipments of seed.

Of considerable interest to the local trade is the recent announcement by the Spanish government of an embargo on the export of olive oil during the present month due to shortage.

It is the belief of many dealers that this regulation will continue in effect throughout the summer. With present supplies of olive oil none too plentiful, an advance is anticipated shortly.

Decreasing stocks due to heavy demand and the fact that catches of oil producing fish are below normal and the fish less fat than last year offer the chief basis for the rising market on fish oils. Crude fish oils in particular are receiving a heavy call from Europe. England is now asking for 5000 bbl. of crude menhaden oil, without response, because producers are unwilling to hold the oil until shipping space can be obtained.

On the domestic side, with the leather, steel and paint industries gradually increasing production, the buying in these quarters is increasing in volume.

SHELLAC:—There is no noteworthy change in the shellac situation. Now and then a few bags appear on the market but are quickly bought up. Sales of a few packages of V. S. O. at $1.15 were reported this week, with dealers asking 90c. for orange superfine, and 80c. for A.C. garnet grade; bleached, bone dry is held at an even $1.00. No T.N. or D.C. is offered and the other grades in only a very limited quantity.

Although there were fairly heavy arrivals from Calcutta last week, the entire amount went to fill old orders. The arrival of the May steamers from Calcutta is expected within the next six weeks, but these shipments will likewise go to cover previous sales.

Contrary to earlier reports, information comes now that supplies in Calcutta are not as plentiful as was anticipated. It appears unlikely that the situation will be relieved before fall.

NAVAL STORES:—Eight years ago spirits of turpentine attained the high mark of $1.19 per gal. Following a daily advance, the price at this writing is $1.04-1.06, with indications of a further jump. Continued heavy demand from abroad with strong domestic buying is given as the reason. London is reported the heaviest buyer. Nearly all the old stocks have been sold and the South is being given no opportunity to accumulate stocks. There is practically no spot material to be found in New York.

St. Louis, Mo., June 9.

A decided increase in demand for certain of the heavy chemicals, particularly sulphuric acid, is reported by local producers. With this development, naturally, has come a firmer feeling and in some cases appreciable price advances.

The fact that the contract renewal season is close at hand explains the increasing number of inquiries. A good deal of spot business is being consummated, however. While much of the trading in heavy chemicals on the mid-West market still gives signs of mere hand-to-mouth buying, the feeling also is creeping in that prices in most branches of the market have reached the bottom and that henceforth any fluctuations will have an upward tendency.

In the lines where higher prices are being asked than was the case a fortnight ago, buyers are reluctant to meet the advance and the market has developed an endurance test between buyers and sellers. Sales are reported at the higher prices, though admittedly few, but the interest in the market at the range of a week or two ago is keener and the general tone of the St. Louis market is firmer.

SULPHURIC ACID:—The demand for this chemical is characterized as very strong, especially from the fertilizer manufacturers. These interests have held aloof from the market for some time, awaiting the traditional "good time to buy." Indications are that they consider that time here or close at hand, for both orders and bona fide inquiries are reported more numerous and involving greater tonnage than has been the case for many months. The 60 per cent grade is now quoted at $12.50 to $14, according to quantity; 66 per cent sulphuric acid is held at $18 a ton. The higher degree of this acid, oleum, is quoted at $25 a ton and is reported in good demand on the part of dye and explosives interests. It is understood here that the increasing scope of operations in the oil well fields has produced a strong demand for torpedoes which in turn is being reflected in the sales of sulphuric acid.

MURIATIC ACID:—A satisfactory amount of business is being transacted in this line, producers claim. The price is stationary at $22 a ton for the 18 per cent grade, but is more firm than was the case a few weeks ago.

SODIUM SULPHATE (Salt Cake):—Greater activity is reported in this branch of the market, too, with prices varying between $19 and $20 a ton.

SODIUM BISULPHATE (Niter Cake):—Business in this department is reported slightly improved, some deals having been transacted at $4 to $5 a ton.

NITRIC ACID:—The market for this chemical is not showing great activity, the prevailing quotation for 38 Baumé being 10 @ 10½c. per pound.

ZINC CHLORIDE:—The demand for this product from the manufacturers of creosoting oils continues unabated, due to the heavy Government orders for railroad ties.

ZINC OXIDE:—An unusual situation is reported in the local zinc oxide market, namely, that for the first time in more than a year the market is extremely active during the period when the announcement of quarterly price changes is expected momentarily. Under ordinary conditions the weeks preceding the expected announcement of new prices are practically devoid of business. This week and last, however, heavy sales of zinc oxide both for domestic and foreign account are reported at 8 to 9c. per lb., according to lead sulphate contents, in carload lots and 8½ to 9½c. per lb. in less than carload lots.

Chicago, June 10.

Gradual improvement in local trade conditions which were noted last month are continuing as June advances, with no spectacular changes in any line except flotation oils. With gross sales for the month figuring up to a comfortable total, collections getting in better shape and a knowledge that overstock and second hands have been reduced to a point where manufacturing conditions have some bearing on prices, the outlook, from the jobbers' standpoint, is more favorable than it has been at any time since last November.

Inquiries are plentiful and sales are being made in reasonable quantity. As yet, however, no long term contracts are being made, jobbers themselves being disinclined to tie up for any great time on the basis of existing low prices.

With 66-deg. sulphuric holding at $20, with sales in normal quantities, practically the entire line of heavy chemicals remains very firm. Sodium hydroxide (caustic soda) is up about 30c., now selling at $2.80, while sodium bichromate, under light demand, has fallen a little, to 7¾c.

No appreciable changes have occurred in the coal-tar line, benzol still selling at 25c. A considerable market for benzol had developed in garage sales to auto owners, when benzol was cheaper than gasoline, but now that the price is higher, this selling has ceased. Commercial demands are sufficient to hold the price firm, however.

Vegetable oils remain very firm in price, with the market rapidly absorbing all offerings.

Two cents has been added to the price of the best grade of steam distilled pine oil, and turpentine has been imitating a rocket, the price on crude advancing 2 or 3c. every day for the past two weeks, and now ranging from $1.05 to $1.10. This has been caused by heavy demand and a stock on hand of only about one-third normal for this time of year. Jobbers are a unit, however, in believing present price to be too high, saying that 85 cents will probably be the figure at which it will ultimately rest.

General Chemicals

WHOLESALE PRICES IN NEW YORK MARKET JUNE 9, 1919

Acetic anhydride	lb.	$0.52 —	$0.60
Acetone	lb.	.15 —	.15½
Acid, acetic, 28 per cent	cwt.	2.50 —	3.00
Acetic, 56 per cent	cwt.	5.50 —	6.00
Acetic, glacial, 99½ per cent, carbnye	cwt.	12.00 —	14.00
Boric, crystals	lb.	.13½ —	.14½
Boric, powder	lb.	.13½ —	.14½
Hydrochloric, tech. 20 deg	cwt.	1.50 —	3.00
Hydrofluoric, 52 deg	lb.	.10 —	.11
Lactic, 44 per cent. tech	lb.	.14 —	.17
Lactic, 22 per cent. tech	lb.	.05 —	.06
Molybdic, C. P	lb.	4.50 —	5.50
Nitric, 40 deg	lb.	.07 —	.08
Nitric, 42 deg	lb.	.07 —	.08
Oxalic, crystals	lb.	.23 —	.28
Phosphoric, Ortho, 50 per cent. solution	lb.	.07½ —	.10
Picric	lb.	.30 —	.40
Pyrogallic, resublimed	lb.	2.45 —	2.55
Sulphuric, 60 deg., tank cars	ton	11.00 —	13.00
Sulphuric, 60 deg., drums	ton	17.00 —	.....
Sulphuric, 60 deg., carboys	ton	20.00 —	.....
Sulphuric, 66 deg., tank cars	ton	16.00 —	18.00
Sulphuric, 66 deg., drums	ton	21.00 —	.....
Sulphuric, 66 deg., carboys	ton	25.00 —	.....
Sulphuric, fuming, 20 per cent.(oleum) tank cars	ton	20.00 —	22.00
Sulphuric, fuming, 20 per cent.(oleum) drums	ton	25.00 —	.....
Sulphuric, fuming, 20 per cent.(oleum) carboys	ton	30.00 —	.....
Tannic, U. S. P	lb.	1.30 —	1.40
Tannic (tech.)	lb.	.42 —	.60
Tartaric, crystals	lb.	.82 —	.85
Tungstic, per lb. of WO_3	lb.	1.20 —	1.40
Alcohol, Ethyl	gal.	4.00 —	4.85
Alcohol, Methyl	gal.	1.25 —	1.30
Alum, ammonia lump	lb.	.03½ —	.04½
Alum, potash lump	lb.	.08½ —	.10
Alum, chrome lump	lb.	.15 —	.....
Aluminium sulphate, commercial	lb.	.01½ —	.03
Aluminium sulphate, iron free	lb.	.02½ —	.03
Aqua ammonia, 26 deg., carboys	lb.	.06½ —	.08
Ammonia, anhydrous, cylinders (100-150 lb.)	lb.	.30 —	.....
Ammonium carbonate, powder	lb.	.12½ —	.13½
Ammonium chloride, granular(white salammoniac)	lb.	.13 —	.14
Ammonium chloride, granular(gray salammoniac)	lb.	.13 —	.14
Ammonium nitrate	lb.	.17 —	.20
Ammonium sulphate	lb.	.05½ —	.06
Amyl acetate	gal.	3.50 —	3.75
Arsenic, oxide, lumps	lb.	.09 —	.09½
Arsenic, sulphide, powdered	lb.	.30 —	.32
Barium chloride	ton	80.00 —	90.00
Barium dioxide (peroxide)	lb.	.19 —	.24
Barium nitrate	lb.	.10 —	.11
Barium sulphate (precip.) (blanc fixe)	lb.	.01½ —	.03
Bleaching powder (see calcium hypochlorite)		..... —	.....
Blue Vitriol (see copper sulphate)		..... —	.....
Borax (see sodium borate)		..... —	.....
Brimatone (see sulphur, roll)		..... —	.....
Bromine	lb.	.40 —	.50
Calcium acetate	lb.	.02 —	.02½
Calcium carbide	lb.	.05½ —	.06
Calcium chloride, fused, lump	ton	19.00 —	25.00
Calcium chloride, granulated	lb.	.01¼ —	.02
Calcium hypochlorite (bleaching powder)	cwt.	1.25 —	2.00
Calcium peroxide	lb.	1.50 —	1.70
Calcium phospbate, monobasic	lb.	.22 —	.23
Calcium sulphate, precipitated	lb.	.10 —	.20
Carboo bisulphide	lb.	.05½ —	.06
Carbon tetrachloride, drums	lb.	.11 —	.14
Carbonyl chloride (phosgene)	lb.	.75 —	1.00
Caustic potash (see potassium hydroxide)		..... —	.....
Caustic soda (see sodium hydroxide)		..... —	.....
Chlorine, gas, liquid-cylinders (100 lb.)	lb.	.05 —	.08
Cobalt oxide	lb.	1.60 —	1.65
Copperas (see iron sulphate)		..... —	.....
Copper carbonate, green precipitate	lb.	.28 —	.31
Copper cyanide	lb.	.65 —	.70
Copper sulphate, crystals	lb.	.07 —	.08
Cream of tartar (see potassium bitartrate)		..... —	.....
Epsom salt (see magnesium sulphate)		..... —	.....
Formaldehyde, 40 per cent	lb.	.20 —	.21
Glauber's salt (see sodium sulphate)		..... —	.....
Glycerine	lb.	.21 —	.23
Iodine, resublimed	lb.	4.25 —	4.30
Iron oxide, red	lb.	.03 —	.18
Iron sulphate (copperas)	cwt.	1.00 —	1.75
Lead acetate, normal	lb.	.12½ —	.15
Lead arsenate (paste)	lb.	.15 —	.18
Lead nitrate, crystals	lb.	.85 —	.86½
Litharge	lb.	.09½ —	.10½
Lithium carbonate	lb.	1.50 —	.....
Magnesium carbonate, technical	lb.	.12 —	.14
Magnesium sulphate, U. S. P.	100 lb.	2.70 —	2.85
Magnesium sulphate, commercial	100 lb.	2.50 —	2.60
Nickel salt, double	lb.	.13 —	.15
Nickel salt, single	lb.	.11½ —	.14
Phosgene (see carbonyl chloride)		..... —	.....
Phosphorus, red	lb.	.55 —	.65
Phosphorus, yellow	lb.	.26 —	.37
Potassium bichromate	lb.	.29 —	.33
Potassium bitartrate (cream of Tartar)	lb.	.52½ —	.55
Potassium bromide, granular	lb.	.49 —	.50
Potassium carbonate, U. S. P.	lb.	.65 —	.70
Potassium carbonate, crude	lb.	.11 —	.14
Potassium chlorate, crystals	lb.	.25 —	.31
Potaseium cyanide, 98-99 per cent	lb.	Nominal	
Potassium hydroxide (caustic potash)	lb.	.35 —	.45
Potassium iodide	lb.	3.30 —	3.40
Potassium nitrate	lb.	.19 —	.22
Potassium permanganate	lb.	.60 —	.65
Potassium prussiate, red	lb.	.80 —	.95
Potassium prussiate, yellow	lb.	.27 —	.40
Potassium sulphate	ton	225.00 —	.....
Rochelle salts (see sodium potas. tartrate)		..... —	.....
Salammoniac (see ammonium chloride)		..... —	.....
Sal soda (see sodium carbonate)		..... —	.....
Salt cake	ton	12.00 —	18.00
Silver cyanide	oz.	1.19 —	.....
Silver nitrate	oz.	.67 —	.69
Soda ash, light	100 lb.	$1.50 —	$1.75
Soda ash, dense	100 lb.	2.00 —	2.25
Sodium acetate	lb.	.06 —	.08
Sodium bicarbonate	100 lb.	2.25 —	2.50
Sodium bichromate	lb.	.07½ —	.09
Sodium bisulphate (nitre cake)	ton	5.00 —	10.00
Sodium bisulphite	lb.	.05 —	.07
Sodium borate (borax)	lb.	.07½ —	.08
Sodium carbonate (sal soda)	100 lb.	1.30 —	1.60
Sodium chlorate	lb.	.15 —	.18
Sodium cyanide	lb.	.30 —	.31
Sodium fluoride	lb.	.14 —	.15
Sodium hydroxide (caustic soda)	100 lb.	2.50 —	2.75
Sodium molybdate	lb.	2.50 —	.....
Sodium nitrate	100 lb.	4.07½ —	.....
Sodium nitrite	lb.	.11 —	.13
Sodium peroxide, powdered	lb.	.25 —	.30
Sodium phosphate, dibasic	lb.	.04½ —	.05
Sodium potassium tartrate (Rochelle salts)	lb.	.43 —	.45½
Sodium prussiate, yellow	lb.	.17½ —	.20
Sodium silicate, solution (40 deg.)	lb.	.01½ —	.02½
Sodium silicate, solution (60 deg.)	lb.	.02½ —	.04½
Sodium sulphate, crystals (Glauber's salts)	cwt.	1.25 —	1.50
Sodium sulphide, crystal, 60-62 per cent (conc)	lb.	.04½ —	.05
Sodium sulphite, crystals	lb.	.03½ —	.04
Strontium nitrate, crystals	lb.	.25 —	.28
Sulphochloride	lb.	.05 —	.05½
Sulphur, crude	ton	32.00 —	35.00
Sulphur dioxide, liquid, cylinders	lb.	.10 —	.12
Sulphur (sublimed), flowers	100 lb.	3.05 —	3.60
Sulphur, roll (brimstone)	100 lb.	2.70 —	3.15
Tin bichloride (stannous)	lb.	.22½ —	.25
Tin oxide	lb.	.60 —	.....
Zinc carbonate, precipitate	lb.	.18 —	.20
Zinc chloride, gran	lb.	.13½ —	.14
Zinc cyanide	lb.	.49 —	.50
Zinc dust	lb.	.09 —	.11
Zinc oxide, dry American	lb.	.09½ —	.11½
Zinc sulphate	lb.	.03¾ —	.04

Coal Tar Products

NOTE—The following prices are for original packages in large quantities:

Alpha naphthol, crude	lb.	$1.00 —	$1.10
Alpha naphthol, refined	lb.	1.40 —	1.50
Alpha naphthylamine	lb.	.40 —	.50
Aniline oil, drums extra	lb.	.22 —	.24
Aniline salts	lb.	.28 —	.33
Anthracene, 80% in drums (100 lb.)	lb.	.90 —	1.00
Benzaldehyde (f.f.c.)	lb.	1.00 —	1.15
Benzidine, base	lb.	1.00 —	1.15
Benzidine, sulphate	lb.	.90 —	1.10
Benzoic acid, U. S. P	lb.	1.00 —	1.10
Benzoate of soda, U. S. P	lb.	.95 —	1.10
Benzol, pure, water-white, in drums (100 lb.)	gal.	.24 —	.28
Benzol, 90%, in drums (100 lb.)	gal.	.23½ —	.27
Benzyl chloride, 95-97%, refined	lb.	.35 —	.40
Benzyl chloride, tech	lb.	.25 —	.35
Beta naphthol benzoate	lb.	4.00 —	4.50
Beta naphthol, sublimed	lb.	.75 —	.80
Beta naphthol, tech	lb.	.45 —	.55
Beta naphthylamine, sublimed	lb.	2.25 —	2.35
Cresol, U. S. P., in druma (100 lb.)	lb.	.18 —	.....
Ortho-cresol, in druma (100 lb.)	lb.	.23 —	.25
Creaylic acid, 97-99%, straw color, in druma	gal.	.85 —	.90
Creaylic acid, 95-97%, dark, in druma	gal.	.80 —	.85
Creaylic acid, 50%, first quality, drums	gal.	.60 —	.....
Dichlorbenzol	lb.	.07 —	.10
Diethylaniline	lb.	1.75 —	2.25
Dimethylaniline	lb.	.50 —	.57
Dinitrobenzol	lb.	.25 —	.30
Dinitroclorbenzol	lb.	.25 —	.28
Dinitronaphthaline	lb.	.45 —	.55
Dinitrotoluol	lb.	.38 —	.45
Dinitrophenol	lb.	.30 —	.32
Dip oil, 25% tar acids, car lots, in drums	gal.	.38 —	.46
Diphenylamine	lb.	.70 —	.75
H-acid	lb.	1.90 —	2.25
Metaphenylenediamine	lb.	1.20 —	1.80
Monochlorbenzol	lb.	.10 —	.14
Monoethylaniline	lb.	1.50 —	1.75
Naphthaline, crushed in bbls. (250 lb.)	lb.	.06 —	.08
Naphthaline, flake	lb.	.06½ —	.07½
Naphthaline, balls	lb.	.09¾ —	.10
Naphthionic acid, crude	lb.	1.00 —	1.25
Nitrobenzol	lb.	.13 —	.15
Nitro-naphthaline	lb.	.40 —	.45
Nitro-toluol	lb.	.17 —	.20
Ortho-amidophenol	lb.	6.00 —	.....
Ortho-dichlor-benzol	lb.	.15 —	.20
Ortho-nitro-phenol	lb.	1.25 —	.....
Ortho-toluidine	lb.	.40 —	.45
Ortho-nitro-toluol	lb.	.27 —	.40
Para-amidophenol, base	lb.	2.75 —	3.50
Para-amidophenol, H. Cl	lb.	3.00 —	3.25
Para-dichlor-benzol	lb.	.06 —	.10
Paranitraniline	lb.	1.00 —	1.25
Para-nitro-toluol	lb.	1.35 —	1.50
Paraphenylenediamine	lb.	3.00 —	3.25
Para toluidine	lb.	1.50 —	1.75
Phthalic anhydride	lb.	1.75 —	2.15
Phenol, U. S. P., druma (dest.), (240 lb.)	lb.	.08 —	.09
Pyridin	gal.	2.50 —	.....
Resorcin, technical	lb.	3.50 —	3.75
Resorcin, pure	lb.	6.50 —	7.75
Salicylic acid, tech., in bbls. (110 lb.)	lb.	.20 —	.30
Salicylic acid, U. S. P	lb.	.25 —	.35
Salol	lb.	.75 —	.80
Solvent naphtha, water white, in drums, 100 gal.	gal.	.20 —	.25
Solvent naptha, crude, heavy, in drums, 100 gal.	gal.	.18 —	.20
Sulphanilic acid, crude	lb.	.25 —	.30
Toluidine	lb.	2.15 —	2.50
Toluidine, mixed	lb.	.45 —	.80
Toluol, in tank cars	gal.	.22 —	.24
Toluol, in druma	gal.	.23 —	.30
Xylidine, drums, 100 gal	lb.	.40 —	.45
Xylol, pure, in drums	gal.	.37 —	.45
Xylol, pure, in tank cars	gal.	.35 —	.....
Xylol, commercial, in drums, 100 gal	gal.	.30 —	.40
Xylol, commercial, in tank cars	gal.	.30 —	.....

Waxes

Prices based on original packages in large quantities.

Beeswax, natural crude, yellow	lb.	$0.40	—	$0.43
Beeswax, refined, yellow	lb.	.45	—	.47
Beeswax, white pure	lb.	.62	—	.68
Carnauba, No. 1	lb.	.80	—	.85
Carnauba, No. 2, regular	lb.	.65	—	.72
Carnauba, No. 2, North Couotry	lb.	.55	—	.60
Carnauba, No. 3, North Country	lb.	.46	—	.48
Ceresin, yellow	lb.	.16	—	.18
Ceresin, white	lb.	.18	—	.20
Japan	lb.	.13	—	.19
Paraffine waxes, crude match wax (white) 105-110 m.p.	lb.	.06	—	.07½
Paraffine waxes, crude scale, 117-119 m.p.	lb.	.06	—	.07½
Paraffine waxes, crude scale, 124-126 m.p.	lb.	.07	—	.....
Paraffine waxes, refined, 118-120 m.p.	lb.	.08¼	—	.08¾
Paraffine waxes, refined, 123-125 m.p.	lb.	.08½	—	.09½
Paraffine waxes, refined, 128-130 m.p.	lb.	.09½	—	.10
Paraffine waxes, refined, 130-132 m.p.	lb.	.10½	—	.11
Paraffine waxes, refined, 133-135 m.p.	lb.	.11½	—	.12
Paraffine waxes, refined, 135-137 m.p.	lb.	.12½	—	.....
Stearic acid, single pressed	lb.	.18	—	.19
Stearic acid, double pressed	lb.	.20	—	.21
Stearic acid, triple pressed	lb.	.22	—	.24
Spermaceti	lb.	.30	—	.32

Flotation Oils

All prices are f.o.b. New York, unless otherwise stated, and are based on carload lots. The oils in 50-gal. bbls., gross weight, 500 lb.

Pine oil, steam dist., sp. gr., 0.930-0.940	gal.	$0.70	
Pine tar oil, ref., sp. gr. 1.025-1.035	gal.	.45	
Pine tar oil, ref., sp. gr. 1.025-1.035 tank cars f.o.b. Jacksonville, Fla.	gal.	.33	
Pine tar oil, double ref., sp.gr. 0.965-0.990	gal.	.58	
Pine tar, ref., thin, sp. gr., 1.080-1.960	gal.	.34	
Turpentine, crude, sp. gr., 0.900-0.970	gal.	.61	
Hardwood oil, f.o.b. Mich., sp. gr., 0.960-0.990	gal.	.24	
Hardwood oil, f.o.b. Mich., sp. gr., 1.06-1.08	gal.	.24	
Pinewood creosote, ref	gal.	.48	

Naval Stores

The following prices are f.o.b., New York, for carload lots.

Rosin B-D, bbl	280 lb.	$11.60	—	$12.25
Rosin E-I	280 lb.	12.20	—	12.45
Rosin K-N	280 lb.	14.10	—	14.45
Rosin W. G.-W. W	280 lb.	15.30	—	15.65
Wood rosin, bbl	280 lb.	11.95	—	.....
Spirits of turpentine	gal.	1.04	—	1.06
Wood turpentine, steam dist	gal.	.90	—	.....
Wood turpentine, dest. dist	gal.	.80	—	.....
Pine tar pitch, bbl	200 lb.	8.00	—	8.25
Tar, kiln burned, bbl. (500 lb.)	bbl.	12.50	—	13.50
Retort tar, bbl	280 lb.	13.50	—	14.50
Rosin oil, first run	gal.	.68	—	.78
Rosin oil, second run	gal.	.70	—	.80
Rosin oil, third run	gal.	.82	—	.83
Rosin oil, fourth run	gal.	.85	—	.95

Solvents

73-76 deg., steel bbls. (85 lb.)	gal.	$0.33½	
70-72 deg., steel bbls. (85 lb.)	gal.	.31½	
68-70 deg., steel bbls. (85 lb.)	gal.	.30½	
V. M. and P. naphtha, steel bbls. (85 lb.)	gal.	.23½	

Oils

VEGETABLE

Unless otherwise noted, the following prices are f.o.b., New York.

Castor oil, No. 3, in bbls	lb.	$0.19	—	$0.20
Castor oil, AA, in bbls	lb.	.21	—	.22
China wood oil, in bbls	lb.	.20	—	.22
Cocoanut oil, Ceylon grade, in bbls	lb.	.17	—	.17½
Cocoanut oil, Cochin grade, in bbls	lb.	.18½	—	.19½
Corn oil, crude, in bbls	lb.	.19½	—	.20½
Cottonseed oil, crude (f.o.b. mill)	lb.	.17½	—	.20
Cottonseed oil, summer yellow	lb.	.25	—	.26
Cottonseed oil, winter yellow	lb.	.26	—	.27
Linseed oil, raw, car lots	gal.	1.60	—	1.70
Linseed oil, raw, tank cars	gal.	1.52	—	1.56
Linseed oil, boiled, car lots	gal.	1.58	—	1.60
Olive oil, commercial	gal.	2.10	—	2.25
Palm, Lagos	lb.	.16½	—	.18
Palm, bright red	lb.	.16	—	.17
Palm, Niger	lb.	.15	—	.16
Peanut oil, crude, tank cars (f.o.b. mill)	lb.	.22	—	.23
Peanut oil, refined, in bbls	lb.	.26	—	.27
Rapeseed oil, refined in bbls	gal.	1.50	—	1.55
Rapeseed oil, blown, in bbls	gal.	1.58	—	1.60
Soya bean oil (Manchurian), in bbls., N. Y.	lb.	.17½	—	.18
Soya bean oil, tank cars, f.o.b., Pacific coast	lb.	.15½	—	.15½

FISH

Winter pressed Menhaden	gal.	$0.90	—	$0.92
Yellow bleached Menhaden	gal.	.92	—	.93
White bleached Menhaden	gal.	.94	—	.95
Blown Menhaden	gal.	1.00	—	1.02

Miscellaneous Materials

All Prices f.o.b., N. Y.

Barytes, domestic, white, floated	ton	$25.00	—	$36.00
Barytes, off color	ton	22.00	—	27.00
Blanc fixe, dry	lb.	.03½	—	.04½
Blanc fixe, pulp	ton	30.00	—	45.00
Casein	lb.	.16	—	.18
Chalk, English, extra light	lb.	.05	—	.07
Chalk, English, light	lb.	.04½	—	.06
Chalk, English, dense	lb.	.04	—	.05
China clay (Kaolin), imported, lump	ton	35.00	—	.....
China clay (Kaolin), imported, powdered	ton	60.00	—	.....
China clay (Kaolin), domestic, lump	ton	10.00	—	20.00
China clay (Kaolin), domestic, powdered	ton	25.00	—	40.00
Feldspar	ton	11.00	—	15.00
Fluorspar, acid grade, lump, f.o.b. mines	net ton	$30.00	—	$35.00
Fluorspar, acid grade, ground, f.o.b. mines	net ton	35.00	—	40.00
Fuller's earth, domestic, powdered	ton	30.00	—	40.00
Fuller's earth, imported, powdered	ton	.....	—	.....
Pumice stone, imported	lb.	.03	—	.06
Pumice stone, domestic	lb.	.02½	—	.....
Shellac, TN	lb.	.60	—	.....
Shellac, D.C	lb.	.....	—	.....
Shellac, V. S. O	lb.	.....	—	.....
Shellac, Diamond I	lb.	.....	—	.....
Shellac, orange, fine	lb.	.73	—	.....
Shellac, orange, superfine	lb.	.75	—	.....
Shellac, A.C. garnet	lb.	.63	—	.....
Shellac, bleached, bone dry	lb.	.....	—	.....
Shellac, bleached, fresh ground	lb.	.....	—	.....
Soapstone	ton	15.00	—	25.00
Talc, domestic	ton	16.00	—	60.00
Talc, imported	ton	55.00	—	60.00

Refractories

Following prices are f. n. b. works:

Chrome brick	net ton	90–100 at Chester, Penn.
Chrome cement	net ton	45–50 at Chester, Penn.
Clay brick, 1st quality fireclay	net ton	35–45 at Clearfield, Penn.
Clay brick, 2nd quality	net ton	30–35 at Clearfield, Penn.
Magnesite, dead burned	net ton	50–55 at Chester, Penn.
Magnesite brick, 9 x 4½ x 2½ in.	net ton	80–90 at Chester, Penn.
Silica brick	net ton	41–45 at Mt. Union, Penn.

Ferro-alloys

All prices f. o. b. works.

Ferro-carbon-titaaium, 15-18%, f.o.b. Niagara Falls, N. Y	net ton	$220.00	—	.....
Ferro-chrome, per lb. of Cr. contained, 6–8% carbon	lb.	32	—	$0.40
Ferro-chrome, per lb. of Cr. contained, 2–4% carbon	lb.	.70	—	.....
Ferro-manganese, 70-80% Mn	gross ton	100.00	—	125.00
Spiegeleisen, 16-20% Mn	gross ton	40.00	—	50.00
Ferro-molybdenum, per lb. of Mo	lb.	2.50	—	3.00
Ferro-silicon, 50%	gross ton	90.00	—	115.00
Ferro-silicon, 75%	gross ton	150.00	—	175.00
Ferro-silicon, 10–15%	gross ton	45.00	—	60.00
Ferro-tungsten, 70-80%, per lb. of contained W	lb.	1.30	—	1.60
Ferro-uranium, 35-50% of U	lb.	7.00	—	.....
Ferro-vanadium, 30-40%, per lb. of contained V.	lb.	5.50	—	7.00

Resales and overstocks make above prices approximate.

Ores and Semi-finished Products

Chrome ore, 35-40%, Cr_2O_3	unit	$0.70		
Chrome ore, 48% and over	unit	1.00	—	$1.25
Coke, foundry, f.o.b. mines	net ton	4.50	—	5.00
Coke, furnace, f.o.b. mines	net ton	4.00	—	5.00
Petroleum coke, f.o.b. Atlantic seaboard	net ton	16.00	—	16.50
Fluorspar, gravel, f.o.b. mines	net ton	20.00	—	25.00
Manganese ore, 45% Mn and over	unit	.75	—	.85
Manganese ore, chemical (MnO_2)	gross ton	60.00	—	70.00
Molybdenite, 85% MoS_2, per lb. of MoS_2	lb.	.75	—	.85
Tungsten, Scheelite, 60% WO_3 and over per unit of WO_3	unit	9.00	—	10.00
Tuogsten, Wolframite, 60% WO_3 and over, per unit of WO_3	unit	6.50	—	8.00
Uranium oxide, 96%	lb.	.....	—	.....
Vanadium pentoxide, 99%	lb.	6.00	—	.....
Pyrites, foreign, lump	unit	.17	—	.....
Pyrites, foreign, fine	unit	.17	—	.....
Pyrites, domestic, fine	unit	.14	—	.....
Ilmenite, 50% TiO_2	net ton	30.00	—	.....
Rutile, 95% TiO_2	net ton	200.00	—	.....
Carnotite, minimum 2% U_3O_8, per lb. of U_3O_8	lb.	3.00	—	3.25

Resales and overstocks make above prices approximate.

Plant Materials and Supplies

In carload lots, New York, unless otherwise stated.

BUILDING MATERIALS

Portland cement, at dock, without baga	bbl.	$2.30
Lump lime, common, including container	300 bbl.	2.65
Common brick, at dock	M.	15.00
Hollow building tile, } 8x12x12	M.	194.40
At factory, Perth Amboy, N. J. } 12x12x12	M.	291.60
Yellow pine, 3x4 to 8x8, 20-24 ft. long	M.	40.00
Yellow pine, 3x4 to 8x8, 20-24 ft. long at Chicago	M.	39.50
Yellow pine, 3x4 to 8x8, 20-24 ft. long at St. Louis	M.	37.00
Roofinga, tar felt (14 lb. per 100 sq.ft.)	ton	50.00
Roofinga, tar pitch (in 400-lb. bbl.)	ton	19.00
Roofings, asphalt pitch	ton	30.00
Roofings, asphalt felt	ton	65.00
Roofings, slate-surfaced shingles, per roll of 108 sq.ft.		2.10
Roofings, slate-finished shingles, 100 sq.ft.		5.50
Linseed oil, raw in barrels	gal.	1.76
Linseed oil, 5 gal. cans	gal.	1.89
Red lead, dry, 100 lb. keg	lb.	.13
Red lead, in oil, 100 lb. keg	lb.	.14½
Red lead, dry, 5 lb. cans	lb.	.15
Red lead, in oil, 5 lb. cans	lb.	.16½
White lead, dry and in oil, 100 lb. keg	lb.	.13¼
White lead, dry and in oil, 25 and 50 lb. kegs	lb.	.13½
White lead, dry and in oil, 5 lb. cans	lb.	.15

STRUCTURAL STEEL, MILL, PITTSBURGH

Beams and channels, 3 to 15-in	100 lb.	$2.45
Angles, 3 to 6-in., ¼-in. thick	100 lb.	2.45
Tees, 3-in. and larger	100 lb.	2.45
Plates	100 lb.	2.66
Rivets, structural, ⅞-in. and larger	100 lb.	4.20
Rivets, conchead for boilers, ⅞-in. and larger	100 lb.	4.30
Sheets, No. 28 black	100 lb.	4.35
Sheets, No. 10 blue annealed	100 lb.	3.55
Sheets, No. 28 galvanized	100 lb.	5.70

For painted corrugated sheets, add 30c. per 100 lb. for 25 to 28 gage; 25c. for 19 to 24 gage; for galvanized corrugated sheets, add 15c., all gages.

INDUSTRIAL

Financial, Construction and Manufacturers' News

Construction and Operation

Alabama

CALVERT—The National Reduction Co. plans to build a rosin and turpentine plant. A. D. Little, Inc., 30 Charles River Rd., Cambridge, Mass., architect.

Arizona

HILLTOP—The Ajax Metal Mining Co. plans to build a 150-ton flotation mill. N. P. Wilson, manager.

HILLTOP—The Hilltop Mining & Smelting Co. plans to build a smelter. O. Fife, manager.

MESA—The City Council plans an election soon to vote on $60,000 bonds for extensions to the gas plant, etc.

California

AVALON—The city plans election soon to vote on $55,000 bonds for the construction of a gas plant on Catalina Island, here.

BENICIA — Kulman, Salz & Co., 603 Wells-Fargo Bldg., San Francisco, is having plans prepared by J. A. Wilcox, engineer, c/o owner, for the construction of a 3-story, 103 x 154-ft. tannery. Estimated cost, $60,000.

JULIAN—F. Tolbat Co., 2115 Logan Ave., San Diego, plans development at its mine here, to include the construction of a mill having a daily capacity of 20 tons. J. W. Lyons, supt.

Connecticut

EAST LYME—The White Beach Sanatorium, c/o Dr. S. J. Maher, 212 Orange St., New Haven, plans to build a sewage disposal plant at the sanatorium for tubercular children. Ford, Buck & Sheldon, Inc., 60 Prospect St., Hartford, engineers.

Florida

JACKSONVILLE — The Virginia-Carolina Chemical Co., 11 South 12th St., Richmond., Va., has awarded the contract for the construction of a 46 x 240-ft. factory on Mills St., here, to Huggers Bros., Bill Bldg., Montgomery, Ala. Estimated cost, $250,000. Noted April 1.

Georgia

ATLANTA — Adair & McCarty Bros., Walton Bldg., are having plans prepared by Lockwood, Greene & Co., engineers, Healy Bldg., for improvements to the fertilizer plant, including a new acidulating unit. Estimated cost, $25,000.

Illinois

VENICE—The Barber Asphalt Co. has awarded the contract for the construction of an oil refinery, to the Fruin-Colnon Construction Co., Merchants-Laclede Bldg., St. Louis, Mo. Estimated cost, $150,000.

WOOD RIVER—The White Star Refining Co., Avery and Grand Trunk Ry., has purchased a site and plans to build a petroleum refinery and pipe line from Wood River to the Mississippi River. Estimated cost, $300,000.

Iowa

FAIRPORT—The Commissioner of Fisheries, Department of Commerce, Washington, D. C., received bids for the construction of a laboratory building at the Biological Station here, from the Walsh Construction Co., 114½ West 3rd St., Davenport, $82,000; J. W. Hopp, 403 Granby Bldg., Cedar Rapids, $84,000; J. Solar, 5th and Cedar Sts., Davenport, $88,000. Noted May 15.

Kansas

ARKANSAS CITY—The city will soon award the contract for the construction of sanitary sewers and a disposal plant. C. E. McCrae, Republic Bldg., Kansas City, Mo., engineer.

Maryland

BALTIMORE—Johns Hopkins University, 321 Druid Hill Ave., has awarded the contract for the construction of a 1-story, 50 x 150-ft. addition to its chemical laboratory on Charles Street Ave., to Frainie Bros. & Haigley, 18 Clay St. Estimated cost, $55,000.

CURTIS BAY (Baltimore P. O.)—The Associated Chemical Co., Pennington Ave. and Cabin Branch, has awarded the contract for the construction of a 1-story, 96 x 100 x 155-ft. fertilizer factory, to W. G. Gischel & Co., South Baltimore. Estimated cost, $9600.

SALISBURY—The Farmers & Planters Co., c/o W. P. Ward, 406 Main St., plans to build a 1- and 2-story, 70 x 225-ft. fertilizer plant and warehouse; bone grinders and other fertilizer plant machinery will be installed in same. Estimated cost, $20,000.

SPARROWS POINT—The Bethlehem Steel Corp. plans to double the size of its tinplate plant here, increasing the number of sheet mills by twelve; also build an additional open-hearth furnace. Estimated cost, $25,000,000.

Michigan

SAGINAW—The McNally Vulcanizing Co., 408 Germania St., is having plans prepared by Cowles & Mutcheller, architects, Chase Block, for the construction of a 1-story, 25 x 60-ft. factory on North Park Ave. Plans include the installation of modern machinery for vulcanizing and tire repair work.

Minnesota

INTERNATIONAL FALLS—The city will soon receive bids for the construction of a hydrogen gas plant. Estimated cost, $75,000. W. Glenn, Minneapolis, engineer.

SHERBURN—E. E. Risley, village recorder, will receive bids until June 27 for the construction of a sewage disposal plant, etc. A. Fick, Boone, Ia., engineer.

ST. PAUL—The city will soon receive bids for a septic tank for the sewage disposal plant at Field and Sheridan Aves., 70 x 120-ft., 17 ft. below grade, walls 3 ft. 6 in. thick at bottom, 16 in. thick at grade. C. A. Hausler, City Hall, engineer.

WALNUT GROVE—D. A. Malloy, city clerk, will receive bids in July for the construction of a sewer and a disposal tank. Estimated cost, $50,000. Druar & Smith, 513 Globe Bldg., St. Paul, engineers.

Missouri

LOHMAN—The American Barytes Co., incorporated by W. C. Irwin, J. Hays and others of Jefferson City, plans to build a mill. Estimated cost, $10,000.

ST. LOUIS—The Scullin Steel Co., 6700 Manchester Ave., will build a steel rolling mill at 6700 Knox Ave., having a monthly capacity of 10,000 tons. Estimated cost, $2,000,000. Peril & Marshall, 2 Rector St., New York City, N. Y., engineers.

ST. LOUIS—The United Drug Co., 63 Leon St., Boston, Mass., plans to build an 8-story factory for the manufacture of rubber goods, drugs, etc., at San Francisco Ave. and Kings Highway. Estimated cost, $2,000,000. F. N. De Rosset, general manager.

Montana

CUT BANK—The City Council will soon award the contract for the construction of a sewerage system, to include two sewage disposal plants, septic tank, etc. Estimated cost, $48,000. H. P. Walter, Minot Bldg., Great Falls, engineer.

New Jersey

KEARNY (Arlington P. O.)—The White Tar Co. will soon receive bids for the construction of a 2-story, 100 x 200-ft. office building and factory. Estimated cost, $60,000. J. W. Cowper Co., Fidelity Bldg., Buffalo, N. Y., engineer.

LAMBERTVILLE—The Chemung Iron & Steel Co., 39 Cortlandt St., New York City, plans to build a 1-story, 100 x 380-ft. steel rolling mill here. Estimated cost, $100,000. E. F. Quirk, c/o owner, engineer.

NEWARK—The Patton Paint Co., Chester Ave., plans to build a 2-story, 61 x 121-ft. factory. Estimated cost, $65,000. J. H. & W. Ely, Fireman Bldg., architects and engineers.

New York

BROOKLYN—The Germania Importing Co., 41 Union Sq., New York City, will build a 2-story, 40 x 90-ft. chemical factory at 46th St. and 2nd Ave. Estimated cost, $20,000. O. Ullrich, 371 Fulton St., architect.

BROOKLYN—H. Kohnsten, 537 Columbia St., manufacturer of chemicals, has awarded the contract for the construction of a 1-story, 60 x 100-ft. factory on Columbia St., to Post & McCord, 101 Park Ave., New York City. Estimated cost, $30,000.

EASTWOOD—The Syracuse Rubber Co., Thompson Rd., Syracuse, recently incorporated with $3,000,000 capital, has awarded the contract for the construction of a 3-story, 60 x 200-ft. plant for the manufacture of cord tires for automobiles, to the Shane Steel Construction Co., 2109 Midland Ave., Syracuse.

JOHNSON CITY—Cook, Holland & Russell will soon award the contract for the construction of a factory on Grand Ave. for the manufacture of concrete building blocks. Complete equipment will be installed in same. Estimated cost, $40,000.

PHILADELPHIA—F. X. Baumert Co., Antwerp, is having plant prepared for the construction of a modern milk testing plant and cheese factory. Laboratory equipment will be installed in same. Estimated cost, $30,000.

North Carolina

NAVASSA—The Morris Fertilizer Co., Third National Bank Bldg., Atlanta, Ga., has awarded the contract for the construction of a fertilizer plant, mill building, niter house, etc., to the Elliott Building Co., Hickory. Estimated cost, $450,000.

STATESVILLE—The city plans to extend the water and sewer mains, to include the installation of additional filters, etc. Estimated cost, $150,000. L. B. Bristol, Mayor.

WILMINGTON—The Morris Fertilizer Co., Third National Bank Bldg., Atlanta, Ga., has awarded the contract for the construction of a fertilizer plant, having a capacity of 75,000 tons a year, to the Elliott Building Co., Hickory. Estimated cost, $125,000. Noted March 15.

Ohio

COLUMBUS—The board of trustees of the Ohio State University will soon award the contract for the construction of a 1-story, 140 x 205-ft. chemistry building on the campus. Estimated cost, $85,000. J. N. Bradford, c/o Ohio State University, architect.

COLUMBUS—The Columbus Tire & Rubber Co., Hayden Bldg., plans to build a 1-story, 100 x 340-ft. rubber factory on West Goodale St. Estimated cost, $92,000. Austin Construction Co., East 152nd St., Cleveland, architect.

COLUMBUS—The Henderson Tire & Rubber Co., Bucyrus, has awarded the contract for the construction of a 2-story, 100 x 300-ft. rubber factory on Goodale St., here, to Moor Bros., 1358 Franklin Ave. Estimated cost, $100,000.

ST. PARIS—The city will soon receive bids for the construction of a sewage disposal plant, to include a filter bed and septic tank. Estimated cost, $10,000. P. Lethig, Springfield, engineer.

Oklahoma

OKLAHOMA—The Hazelrigg Laboratories, recently incorporated with $50,000 capital, by J. E. Harbison, treasurer, 310 Mercantile Bldg., and others, plans to build a plant for the manufacture of chemicals.

TULSA—The Hofstra Manufacturing Co., manufacturer of insect powder, plans to install machinery in its plant. Estimated cost, $30,000. J. B. Gibbons, engineer.

TULSA—Dr. L. D. Latham, Bliss Bldg., plans to install a chemical laboratory in connection with the 3-story, 40 x 120-ft. hospital which he plans to build at 18th

and Quincy Sts. Total estimated cost, $100,000. Thompson & Fleming, 222½ Iowa Bldg., architects.

Oregon

CORVALLIS—J. Myers, secretary of the Board of Regents of the State Agricultural College, will soon award the contract for the construction of a 2-story, 56 x 220-ft. engineering laboratory on the college campus. Estimated cost, $130,000. J. V. Nennes, 1040 Chamber of Commerce Bldg., Portland, architect.

PORTLAND — The Portland Rubber Mills, Inc., 368 East 9th St., has awarded the contract for the construction of a 1-story, 75 x 200-ft. factory in South Portland, to T. Muir, Henry Bldg. Estimated cost, $20,000.

SALEM—The Oregon Pulp & Paper Co. will soon receive bids for the construction of a two-machine paper and sulphite pulp mill on the Willamette River. Estimated cost, $1,000,000. C. E. Eaton, Sherman Bldg., Watertown, N. Y., engineer.

Pennsylvania

DEAN—The Haws Refractories Co., Johnstown, plans to build a large firebrick plant here, having a capacity of 100,000 bricks per day. H. L. Tredennick, Johnstown, president.

PHILADELPHIA — The Hess-Bright Manufacturing Co., Front and Erie Sts., plans to build a 2-story, 42 x 105-ft. laboratory. F. R. Watson, 1211 Walnut St., architect.

WISSINOMING—The Quaker City Rubber Co., 629 Market St., has awarded the contract for the construction of a 2-story, 140 x 160-ft. factory, to J. S. Rogers, Drexel Bldg., Philadelphia.

Texas

DALLAS—The State Refining Association, 1403 American Exchange National Bank Bldg., plans to build a skimming plant having a capacity of 500 barrels. S. Bonner, treasurer.

NORTH FORT WORTH—The Bureau of Yards & Docks, Navy Department, Washington, D. C., has awarded the contract for the construction of a helium production plant, to the Central Contracting Co., 520 Beatty Bldg., Houston. Estimated cost, $448,000.

WICHITA FALLS—The committee on Northwest Texas Insane Asylum will soon award the contract for the construction of four buildings for the asylum here, including disposal plant, etc. Estimated cost, $350,000. C. H. Page & Bros., Austin National Bank Bldg., Austin, architect.

Washington

HOQUIAM—The Western Rolling Mills Corp. will soon award the contract for the construction of the first unit of its steel rolling plant to be 70 x 300 ft. J. Johnson, manager.

West Virginia

CAMP HUMPHRIES — The United States War Department, Washington, D. C., will soon receive bids for the construction of an artificial gas plant and distribution system to serve 10,000 people. Lieutenant G. A. Caine, Camp Humphries, engineer.

FAIRMONT—The West Virginia Metal Products Corp., incorporated with $2,500,000 capital stock, plans to build a large brass rolling mill. J. E. Watson, president.

Wisconsin

SHEBOYGAN—The North Star Rubber Co., c/o L. Hoffmaster, 176 16th St., Milwaukee, plans to build a 2-story, 60 x 95-ft. rubber plant on Michigan Ave., here. Estimated cost, $45,000.

Alberta

CALGARY—The City Council has appropriated $350,000 for the construction of a sewage disposal plant.

Ontario

BANCROFT—The Canada Marble Co. plans to build a plant. Estimated cost, $500,000. Architect not selected.

DUNDAS—A. W. Draeseke, chairman of the sewer committee, will receive bids until June 23 for the construction of sewage disposal works, sewage pumping station and force main, out fall sewer, sewage pumping machinery, sprinkler equipment, etc. J. S. Fry, town, clerk. Noted May 1.

HAMILTON—The National Paper Goods Co., Ltd., plans to build a 56 x 100-ft. factory. Estimated cost, $80,000.

KITCHENER—The Imperial Oil Co., Ltd., 181 Brock St., Sarnia, has awarded the contract for the construction of an addition to its oil plant, here, to Shulte Bros. & Co., 35 Albion St., Brantford. Estimated cost, $20,000.

PORT COLBORNE—The Canada Cement Co., 273 Craig St., W., Montreal, Que., plans to build a potash recovering plant. Estimated cost, $150,000.

WELLAND—The Imperial Oil Co., 56 Church St., Toronto, has awarded the contract for the construction of an oil plant, to Schutz Bros., 35 Albion St., Brantford. Estimated cost, $40,000. Noted June 1.

WESTON—The K. & S. Canadian Tire & Rubber Co. is having plans prepared by Hynes, Feldman & Watson, architects, McKennon Bldg., Toronto, for the construction of a 1-story factory. Estimated cost, $80,000.

Coming Meetings and Events

THE AMERICAN CHEMICAL SOCIETY will hold its Fall meeting in Philadelphia, Pa., Sept. 2-6 inclusive.

THE AMERICAN ELECTROCHEMICAL SOCIETY will hold its Fall meeting in Chicago, Sept. 23-25 inclusive.

THE AMERICAN ELECTRO-PLATERS' SOCIETY will hold its 1919 convention in Philadelphia, Pa., July 1-3.

THE AMERICAN FOUNDRYMEN'S ASSOCIATION will hold its 1919 convention in Philadelphia, Sept. 29 to Oct. 4.

THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS will hold its Summer meeting at Boston, Mass., June 18-21. A symposium is planned on electric furnaces.

THE AMERICAN INSTITUTE OF MINING AND METALLURGICAL ENGINEERS will hold its Fall meeting in Chicago, Ill., Sept. 22-27.

THE AMERICAN SOCIETY FOR TESTING MATERIALS will hold its 22nd annual meeting at Atlantic City, N. J., June 24-27. The headquarters will be at the Hotel Traymore.

THE AMERICAN STEEL TREATERS' SOCIETY will hold its first annual convention in Chicago, Ill., Sept. 22-27.

THE FIFTH NATIONAL EXPOSITION OF CHEMICAL INDUSTRIES will be held in Chicago, Ill., Sept. 22-27 inclusive.

THE INSTITUTE OF METALS DIVISION of the A. I. M. E. will hold its next meeting in Philadelphia, Pa., Sept. 29 to Oct. 4.

THE INSTITUTE OF METALS will hold its Autumn meeting in Sheffield, England, Sept. 24-25.

THE INTERALLIED CHEMICAL CONFEDERATION will hold its next meeting in London, July 15-18, 1919.

THE NATIONAL FERTILIZER ASSOCIATION will hold its 26th annual convention the week of June 23 at the Hotel Griswold, Eastern Point, New London, Conn.

THE SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION will hold its 27th annual meeting at Johns Hopkins University, Baltimore, Md., June 25-28.

Industrial Notes

THE CHICAGO PNEUMATIC TOOL CO. has moved its Milwaukee office from Room 1305, Majestic Bldg., to Room 1418 in the same building, where more convenient quarters have been obtained.

THE PRATT ENGINEERING & MACHINE CO., Atlanta, Ga., has been awarded a contract for the erection of a complete fertilizer plant for the Southern Fertilizer & Chemical Co. at Savannah, to cost approximately $500,000. This new plant is to take the place of one recently destroyed by fire and will be ready for operation in September, 1919.

THE BLAW-KNOX CO., Pittsburgh, Pa., manufacturers of steel products, announces the appointment of Mr. J. E. Mason as manager of field sales. For the past four years Mr. Mason has been connected with the McGraw-Hill Co., having been in charge of the Chicago office of *Engineering News-Record* since July, 1917.

THE ANNISTON STEEL CO., Anniston, Ala., announces the appointment of W. W. Tarleton as director of the salvage division, sales department. Mr. Tarleton will be in charge of the sale of iron and woodworking machinery, engines and boilers and miscellaneous equipment recently acquired from the Illinois Car & Equipment Co.

THE BOOTH-HALL CO., designer and builder of electric furnaces, announces removal of the executive and sales office to Rooms 1007-1008 Hearst Bldg., 326 W. Madison St., Chicago, Ill.

THE ELECTROLABS CO., New York, announces that the Paschall Oxygen Co., Philadelphia, will increase the capacity of its plant 25 per cent, making a total of 1,000 Levin cells in operation.

THE AMERICAN STEAM CONVEYOR CORP., Chicago, Ill., announces the appointment of Mr. Charles H. Florandin, formerly of the National Electric and Welding Co., New York, as general manager of its Eastern territory, with headquarters at 110 W. 40th St., New York.

THE MARLAND REFINING CO., Ponca City, Okla., has recently advised its employees that it has determined on a plan for paying labor dividends based upon amount of salary or wages received. The management regards the labor of its employees as an investment by them in the business and will pay them a dividend of its earnings made by capital and their labor. This is said to be the first time that a plan of labor dividends has been tried in the oil business.

SCHAAR & CO., Chicago, Ill., announces the removal to larger quarters at 556-560 W. Jackson Blvd., where the manufacturing, selling and executive departments will be under one roof.

THE UNITED FILTERS CORP., New York, announces the appointment of Mr. C. B. Oliver as manager of the Chicago office with headquarters in the Peoples' Gas Building.

MR. JAMES INGLIS, president of the American Blower Co., sailed from New York on May 15 as a member of a commission appointed to confer with European cotton interests on post-war conditions in the cotton industry throughout the world and with special reference to the proposed world cotton conference to be held in New Orleans next October.

THE COMMITTEE OF THE AMERICAN INSTITUTE OF CHEMICAL ENGINEERS, of which Dr. R. F. Bacon, director of the Mellon Institute, is chairman, is assisting the Government in disposing of chemical plants and surplus stocks of chemicals and apparatus. Much of this material is difficult to store and must be sold at once.

MR. M. H. JONES, who has been connected with the Westinghouse Electric & Manufacturing Co. for the past fifteen years as assistant to the manager of the Philadelphia district, has resigned his position to become sales manager of the Standard Electric & Elevator Co. of Baltimore.

THE ALLIED MACHINERY CO. OF AMERICA has increased its capital stock to $5,000,000, the step being necessitated by the decision of the American International Corp. to group all of its machinery export selling subsidiaries under one head. The Allied Construction Machinery Corp. will be absorbed by the American Machinery Co. of America. The Allied Machinery Co. de France and the Allied Machinery Co. d' Italia will retain their corporate entities, but their parent corporation will be the Allied Machinery Co. of America rather than the American International Corporation as before. This is also true of the Horne Co., Ltd., of Japan, which was purchased early in the year by the American International Corporation. Mr. J. W. Hook will continue as president of the Allied Machinery Co. of America, in general charge of the business. Messrs. F. A. Monroe, S. T. Henry and T. G. Nee have been elected vice-presidents. Mr. Monroe is in charge of the administrative affairs of the company. Mr. Henry is in charge of sales and advertising and Mr. Nee is at present in Japan, devoting his attention to the affairs of the Horne Co., Ltd. Mr. R. P. Redier is general sales manager of the company, with headquarters at Paris.

HAMILTON & HANSELL, INC., New York City, announces the selling of the following electric furnaces: One 1000-lb. Rennerfelt furnace, 400 k.v.a., to the Steel Alloys Co. of America, to be erected at its plant in Bayway, Elizabeth, for the reduction of tungstic acid to metallic tungsten. One 1000-lb. Rennerfelt furnace, 200 k.v.a., to the British American Nickel Co., Ottawa, Canada, to be erected at its Deschene plant in Quebec, for melting nickel. One 150-k.v.a. single-phase pot furnace with its complete

equipment, sold to the Government of the Netherlands, Colonial Department, to be erected at the experimental station in Batavia, Java, Dutch East Indies.

LEEDS & NORTHRUP CO., Philadelphia, Pa., has opened a pyrometer sales and service department at 1304 Monadnock Block, Chicago. A complete standardization equipment will be maintained and certification of thermocouples and of pyrometer equipments will be furnished in terms of standards certified by the United States Bureau of Standards. Particular attention will be given to maintaining equipment after installation. The office will be in charge of Mr. Henry Brewer.

MARDEN, ORTH & HASTINGS, INC., of New York City, moved its dyestuff and intermediate department to Bound Brook, N. J. An office at 136 Liberty Street, New York City, will be maintained for the metropolitan salesmen of the dyestuffs and intermediates department, and also considerable stocks will be carried in New York for the quick deliveries to trade in that vicinity.

THE STANDARD ELECTRIC & ELEVATOR CO., INC., Baltimore, Md., has opened a New York office at 280 Broadway, in charge of C. A. Harrington, formerly sales manager of the company.

Directors of the E. I. du Pont Powder Co. have elected the following new vice-presidents: Charles A. Meade, W. S. Carpenter, Jr., J. B. D. Edge, A. Felix du Pont, William C. Spruance and Charles A. Patterson. These are the recently appointed members of the new executive committee, and their election as vice-presidents follows the custom of the company, which gives the title of vice-president to the active heads of departments.

THE BLAW-KNOX CO., Pittsburgh, Pa., has taken over the manufacture and field operation of the Unl-Form System of reinforced concrete floor and roof construction, which is now incorporated in the steel forms department of the Blaw-Knox Co. and will be known as "Blawforms."

THE WESTINGHOUSE ELECTRIC & MANUFACTURING CO., East Pittsburgh, Pa., announces the appointment of Mr. H. L. Garbutt as manager of the supply division of the San Francisco office of the company.

THE CARBON STEEL CO., Pittsburgh, Pa., announces the return from the aviation service in Italy of Mr. Harry S. Finkenstaedt as Western sales agent.

THE ALKALI EXPORT ASSOCIATION, INC., New York, is composed of five companies: The Pennsylvania Salt Mfg. Co., Philadelphia; The Solvay Process Co., Syracuse, N. Y.; The Michigan Alkali Co., New York; Columbia Chemical Co., Cincinnati; The Hooker Electrochemical Co., Niagara Falls, N. Y.

THE BUFFALO FORGE CO. announces that Mr. C. C. Cheyney has returned to take charge of its Chicago office and store. Lieut. Cheyney was commissioned in the Navy and had charge of the mechanical repair shops at the Naval Aviation Station, Pensacola, Fla. Capt. H. H. Downes, 12th U. S. Engineers (Railway) has returned from France, and expects that after receiving his discharge he will take charge of the Buffalo Forge Co.'s interests in the St. Louis territory.

THE WHEELER CONDENSER & ENGINEERING CO., Carteret, N. J., manufactured and shipped during the month of April 879,900 lb. of seamless drawn brass, copper and tungsten tubes.

THE INTERNATIONAL OXYGEN CO., Newark, N. J., announces the appointment of Mr. Preston Belvin as district sales engineer, in charge of the Pittsburgh district sales work, with headquarters at 1310 National Bank Bldg. The Chicago office of this company has been moved from 223 Railway Exchange Bldg. to 817-820 Chicago Stock Exchange Bldg., with Mr. Philip G. Wesley in charge.

THE SCIENTIFIC UTILITIES CO., INC., New York, manufacturer of laboratory glassware and metal apparatus, with offices at 84 East 10th St., has raised its capital to $30,000.

THE BETSON PLASTIC FIRE BRICK CO., Rome, N. Y., elected Mr. Frank J. Jewell as president and secretary and Mr. Nelson Adams, vice-president and treasurer. The company's products are plastic firebrick for boiler furnace linings and baffle walls and Hi-heat cement for use in the boiler room.

THE CELITE PRODUCTS CO., New York City, announces the appointment of Mr. Edward F. Davis as sales engineer in Northern New Jersey on the application of Sil-O-Cel insulation and Filter-Cel for filtration.

Manufacturers' Catalogs

THE KINITE CO., Milwaukee, has issued a 4-page folder entitled "Kinite, A Patented Alloy Steel."

THE CUTLER-HAMMER MFG. CO., Milwaukee, Wis., calls attention to a six-page folder on melting metal with electrically heated pots.

THE GRISCOLM-RUSSELL CO., New York: Bull. No. 230 illustrates and describes the Reilly water heater.

THE DENVER FIRE CLAY CO., Denver, Colo., calls attention to two new bulletins. Bull. No. 125 on firebrick, metallurgical tile, fire clay, etc., illustrates and describes these products. Bull. No. 100 treats metallurgical clay goods, muffles, crucibles and scorifiers.

THE BUCKEYE DRYER CO., INC., Columbus, Ohio: Cat. No. 3 is a new 44-page booklet which deals with Buckeye dryers for organic and inorganic materials. Many illustrations are given together with descriptive matter.

THE MERRILL CO., San Francisco, Cal., has issued a booklet which gives the comments of the technical press on the Crowe vacuum precipitation process, which is a new method of precipitating cyanide solutions in conjunction with either the Merrill precipitation process or with zinc boxes.

THE AMERICAN LAVA CO., Chattanooga, Tenn., announces a new publication entitled "Lava for Mechanical and Electrical Purposes." This 16-page booklet illustrates and describes nature and physical properties, mechanical properties, electrical properties, uses and cost and composition lava.

THE CHAS. A. SCHIEREN CO., New York City has just received from the press Cat. No. 10, issued April, 1919, on Schieren leather beltings. It is an attractive 40-page booklet dealing with tanning methods, the different qualities of belting, general price list on Duxbak leather belting, leather link belting with price list, round leather belting, wire-screwed solid round belting, cut lacing, hydraulic leather, belt cement wafers, waterproof cement and flyfoot belt dressing. Many illustrations are given in color to illustrate these products. Schieren Engineering Service is a section which give a definite plan for making belting cost less and go further.

New Publications

STANDARD SPECIFICATIONS FOR PURITY OF RAW LINSEED OIL FROM NORTH AMERICAN SEED. Industrial Standards No. 57, published by the Bureau of Foreign and Domestic Commerce.

NEW BUREAU OF STANDARDS PUBLICATIONS: Tech. Paper No. 126. A study of the Goutal method for determining carbon monoxide and carbon dioxide in steels. By J. R. Cain and Earl Pettijohn; No. 76. Aluminium and Its Light Alloys.

NEW UNITED STATES GEOLOGICAL SURVEY PUBLICATIONS: 1:1 Cadmium in 1918. By C. E. Siebenthal (Mineral Resources, 1918, Part 1), published May 8, 1919; 1:21. Gold and Silver in 1917. General Report. By H. D. McCaskey and J. P. Dunlop (Mineral Resources, 1917, Part 1), published May 9, 1919; 1:22. Antimony in 1917. By Edson S. Bastin (Mineral Resources, 1917, Part 1), published May 13, 1919; 11:28. Clay-Working Industries and Building Operations in the Larger Cities in 1917. By Jefferson Middleton. (Mineral Resources, 1917, Part 11), published May 12, 1919; 11:29. Lime in 1917. By G. F. Laughlin. (Mineral Resources, 1917, Part 11), published May 13, 1919.

U. S. DEPT. OF LABOR PUBLICATION on Treatment of Industrial Problems by Constructive Methods. A pamphlet and chart on methods of redesigning labor turnover and improving morale in plant organization.

SUGGESTIONS FOR IMPROVING PLANT ORGANIZATIONS. A report of a survey of 200 plants and works with suggestions for their improvement.

THE CALIFORNIA STATE MINING BUREAU, San Francisco, has issued Bull. 84, which is the third annual report of the State Oil and Gas Supervisor of California for the fiscal year 1917-18.

THE UNITED STATES NATIONAL MUSEUM, Bull. 102, Vol. 1. The Mineral Industries of the United States: The Energy Resources of the United States; A Field for Reconstruction. A survey of the situation in domestic fuels, petroleum and power, made in anticipation of the time when the United States must more systematically employ its energy resources.

Technology, The Journal of the Manchester Municipal College of Technology, Manchester, England. A record of investigations undertaken by members of the college.

NEW BUREAU OF MINES PUBLICATIONS: Bull. 144. Report of a Joint Committee Appointed from the Bureau of Mines and the United States Geological Survey by the Secretary of the Interior to Study the Gold Situation; Tech. Paper 214. Motor Gasoline Properties, Laboratory Methods of Testing, and Practical Specifications. By E. W. Dean; War Minerals Investigations Series No. 12. The Jones Process for Concentrating Manganese Ores, Results of Laboratory Investigations. By Peter Christianson and W. H. Hunter; Minerals Investigations Series No. 13. Cost of Producing Ferro-Grade Manganese Ores. By C. M. Weld and W. R. Crane.

Stocks and Bonds

Closing Bid and Asked Quotations June 11, on N. Y. Stock Exchange

CHEMICAL COMPANIES

	Bid	Ask		Bid	Ask
Am.Ag.Ch.....	108⅛	108¾	Mat.Al.Wk..	35	40
do.pf.....	99⅛	100⅛	Ten. C. & C..	13⅜	14
Barrett Co..	136½	137½	Un. Dyewood.	62	63
do.pf.....	118	119	do. pf.....	97	97½
Gen.Chem.....	180	195	Va.-Car. Ch..	75½	76
do.pf.....	103	107½	do. pf.....	113¼	114
Int.Ag.Ch....	44¼	45			
do. pf.....	84½	85½			

Bonds

Am. Ag. Ch., 1st cv. 5s, '28.....	98½	99
Am. Ag. Ch., cv. db. 5s, '24.....	106½	109
Int. Ag. Ch., 1 mtg. & col. tr. 5s, '32...	82½	83
Va.-Car. Ch., 1 mtg. 5s, '23	97	97½
Va.-Car. Ch., cv. db. 6s, '24	101½	102½

PETROLEUM COMPANIES

	Bid	Ask		Bid	Ask
Asso. Oil Co..	90¾	92	P-A Pet & Tr.	98	98½
Cal. Pet.....	37⅜	38	do. pf.....	167	174
do.pf.....	83	83¾	Pierce Oil....	24⅞	25
Col. G. & E..	55⅜	55½	Royal Dutch..	116½	116⅝
Mex. Pet.....	185½	186	Sinclair O & R	63⅜	64
do. pf.....	105½	110	Texas Co....	273	274
Ohio Cit. Gas..	56⅜	56⅞	Tex. Pac. Ld.		
do. pf.....	...	...	Tr.....	425	500
Ohio Fuel S...	51½	52	Tidewater Oil.	242	248
Okla. P. & R..	10⅛	10⅞			

Bonds

Columbia Gas & Electric, 1 5s, '27.....	88½	89
Col. G. & El., std. 1 5s, '27	88½	...
Pan-Am. Pet. & Tr. 1 6s, '19-'27.....	140	165
Pierce Oil, cv. db. 6s, '24.....	105	106½
Pierce Oil, cv. 5% Notes, '20.....	117½	128
Sin. O. & R. 1 In.7s, '20, with stk. war...	140	150
Sin. O. & R. 1 In. 7s, '20 without stk. war..	99½	100
Texas Co., db. 6s, '31.....	102	102½
Union Oil of Cal. 1 5s, '31.....	93⅜	94⅛
United Fuel Gas 1 mtg. 6s, ser.A, '36....	94½	97

IRON AND STEEL SECURITIES

	Bid	Ask		Bid	Ask
Am. St. F....	97⅛	97⅝	Pitts. Ste. pf..	96	99
Beth. Steel...	88	88⅛	Rep. Iron &		
do. class B.	90½	90⅝	Steel.....	89	90
do. pf., 8%.	114⅛	114⅝	do. pf....	104½	105
do. pf., 7%.	102	110	Sloss Sheff. I.		
Central Fdry.	21½	22	& S.....	65	66
do. pf.....	46	48	do. pf.....	90	94
Col. F. & I...	49	49⅝	Superior Steel.	49	50
do. pf.....	103	125	do. 1 pf....	102	105
Cruc. Steel...	92⅛	92½	Trans. & W.		
do. pf.....	100½	103	Steel.....	56	57
Great No. Ore	47⅛	47⅜	Un. Alloy St..	52	52½
Gulf Sta. Steel	66⅛	68	U.S.C.I.P.&F.	33⅛	33⅜
do. 1 pf....	94	98	do. pf.....	64	65
Lack. Steel...	85	86	U. S. Steel...	108⅛	108⅜
Mid.St.& Ord.	51⅛	51½	do. pf.....	116⅛	116½
Nova Scotia			Va. Coal, I&C.	69	71
Steel.....	87⅛	88			

Bonds

Beth. Steel, 1 ext. gtd. S.F. 5s, '26.....	96½	96⅝
Beth. Steel, 1 In. ref. 5s, Ser. A, '42.....	90⅜	...
Beth. Steel, P. M. & I. S. F. 5s, '36.....	89	89½
Buff. & Susq. Iron, 1 S. F. 5s, '32	91	96
Cent. Found. 1 mtg. S. F. 6s, '21.....	80⅜	82
Col. F. & I., gn. S. F. 5s, '43.....	91	93½
Ill. Steel, db. 4½s, '40.....	84½	86
Ind. Steel, 1 mtg. gtd. 5s, '52.....	97	97⅛
Lack. Steel, 1 5s, '23.....	97	97⅜
Lack. Ste., 1 con. mtg. cv. 5s, Ser. A, '50	93	95½
Mid. St. & Ord., clt. cv. S. F. 5s, '36.....	89⅜	90⅛
Nat. Tube, 1 mtg. gtd. 5s, '52.....	98½	99
Rep. I. & S. S. F. mtg. 5s, '40.....	95	97½
Tenn. C. & I. R.R., gn. 5s, '51.....	93	94
U. S. Steel, S. F. 5s, '63.....	100	104
Va. C., I. & C., 1 5s, '49.....	85½	88½

TN
1
C45
v. 20

Chemical engineering

ENGINEERING

PLEASE DO NOT REMOVE
CARDS OR SLIPS FROM THIS POCKET

UNIVERSITY OF TORONTO LIBRARY

ENGIN STORAGE